ENGINEERING CASE LIBRARY

ECL 121

DEVELOPMENT OF AN ASPIRATOR

Background

A small manufacturing company, Band Company* of Sausalito, California, specialized in the fabrication of special devices and tooling for larger manufacturers. In its own name, the company manufactured resistance welding equipment and spot welded steel decorative grill for architectural use. The tooling manufactured included special welding fixtures for parts of electronic computers, dies for the making of molded plastic items, and machines for production assembly of small products. During the time covered in this case, I was owner of Band Company.

The technical staff of Band Company consisted of my manager, Don, myself and occasional short term consultants. Don has extensive and broad experience in industry. He is a skilled, innovative person who approaches his work with great energy and thoroughness. He does not have an engineering degree. I have a masters degree in mechanical engineering, several years of industrial experience and over 20 years experience in teaching and curriculum and facilities planning. A large share of my experience has been in fluid mechanics.

One of the major purchasers of services and products of Band Company was Airslide Corporation, a medium-sized manufacturer of inflatable life saving devices. Airslide was located in the same building as Band Company. Their products include lift rafts, life preservers and vests and inflatable escape slides for use in jet transport airplanes.

We had, over a period of time, developed a close working arrangement with Airslide Corp. It was not feasible for them to install machine shop and welding shop tools and equipment. On the other hand, these were our basic tools.

Therefore, because we were located close to Airslide Corp. and could offer a service needed by them, we did much of their metal fabrication and assembly. We were also able to provide consultation on problems related to fabrication of their products.

Escape slides

Escape slides are the products that require aspirators, the subject of this case. The purpose of these slides is to provide a means of getting the passengers safely to the ground after an emergency landing which has made it impossible to bring a stairway to the airplane. The exit doors of the airplane are too far from the ground (a distance of about 15 feet) to permit egress without risk of injury. To solve this problem, the emergency slide is now required in all jet airplanes carrying passengers on a scheduled basis.

*Names in this case, except the author's, are fictitious.

 Written by Professor T. J. Zilka, San Francisco State College, with financial support from the National Science Foundation.

The slide resembles an inflatable life raft but is longer and narrower. It is made of neoprene coated nylon fabric. The basic side members are two nearly straight tubes approximately eighteen inches in diameter and twenty-five feet long. These are spaced approximately three feet apart by end tubes and one or more intermediate cross tubes. A sheet of coated fabric stretched between the tubes acts as the surface along which passengers slide while being evacuated from the airplane.

Exhibit 1 explains the procedure to be followed in using the escape slide for emergency evacuation of an airplane. This exhibit is a copy of the type of card placed at each seat of all passenger airplanes in scheduled airline use.

Aspirator—its nature and use

Inflation of the typical slide in use today is by means of an inflation valve commonly called an aspirator. The name "aspirator" comes from the desired action of the valve. For the inflation process these valves utilize high pressure air contained in a pressure bottle in the airplane. The design of the aspirator is such that when the high pressure air passes through suitable passages it creates a negative pressure at the entrance of the aspirator. This entrance is open to the atmosphere. The surrounding air is thus drawn into the inflating slide and supplements that coming directly from the pressure bottle. The object of this type of design is to make it possible to use a minimum size of air bottle to inflate the slide. This objective comes directly from the overall objective in air transportation to keep weight of airplane and necessary equipment to a minimum.

The size of the aspirator is of importance as well as its general shape and proportions. It is desirable to keep total volume of the stowed slide to a minimum. Generally speaking, a flat disc-like shape or a cylinder of small diameter to length ratio are preferable. The requirement of rapid inflation makes it most feasible to have the shortest possible passage from aspirator to slide. It is common practice to mount the aspirator directly in the wall of one of the major tubes of the slide thus eliminating the aspirator-to-slide passage entirely. This arrangement requires that the aspirator also contain a means of tightly closing the opening through which the atmospheric air passes. This closing device is commonly called the "door" of the aspirator.

Exhibit 2 shows the approximate general arrangement of the total equipment used to provide this type of emergency exit. The equipment consists of: the slide, the aspirator, a high pressure air bottle, a release valve on the bottle and hoses and attachment hardware to join the major components together.

Don and I learned that Airslide was not fully satisfied with aspirators available at the time. They were experiencing some difficulties with delivery schedule which gave rise to fears of production interruption. Our close proximity and generally satisfactory delivery on other products apparently gave them some confidence in our ability to perform. They encouraged us to try to design and develop a different type of aspirator. Our thought was that, using it to provide occasional fill-in work, we might complete the development in less than a year. Because the manufacture of the aspirator would be low volume and precise in nature, it fitted well into our plant size and characteristics. The potential profit looked very favorable. Our combination of experience and talents seemed right for the task and it was an interesting challenge. So we decided to undertake the development and to manufacture the valve when it was perfected.

Design specifications

The requirements to be satisfied by the aspirator as they were originally presented to Band Company can be summarized as follows:

Minimum pressure in slide when fully inflated:	2.0 psi
Maximum pressure in slide when fully inflated:	4.0 psi
Maximum inflation time:	12-15 seconds
Volume of slide:	60 cubic feet
Pressure in supply air bottle:	3000 psi
Volume of supply air bottle:	300 cubic inches

These were the specifications used as a basis for the start of development efforts of Band Company.

Existing designs

Before the entry of Band Company into the field, two aspirator designs were widely used in the United States.

These designs are described in exhibits 3 and 4 which are copies of the patents.

Principles of operation

The basic principle of using a high velocity jet to produce a low pressure to draw in another stream of fluid is commonly used in many devices such as: the automobile carburetor, the aerators (anti-splash devices) used in wash basin water faucets, the vacuum devices used in school chemistry laboratories, many types of paint and insecticide sprayers, etc.

For purposes of this narrative, the high velocity primary jet will be called the *inducing* jet. The surrounding air is said to be *induced* to join the inducing jet. Because this inducing action is partially a surface phenomenon, it was generally accepted, for aspirator design, that the surface area per unit of length of jet should be as large as possible for a given cross-sectional jet area.

It is possible to produce pressure in an inflatable device, such as an escape slide, by properly reducing to zero the velocity of an entering stream of air. This effect is commonly called the ram effect. In other words, a stream of air at atmospheric pressure entering the slide at high velocity will produce pressure in the slide above atmospheric when the jet velocity is reduced to zero.

Our problems in starting the design

A search of available literature on inflating devices and various types of devices for inducing fluid flow by means of a high velocity fluid jet revealed a virtually complete lack of information on which to base a new aspirator design. Some of the difficulties were:

1. The most effective ratio between the velocity of the inducing jet and the velocity of induced main stream was not known. Nor was the ideal configuration of the two streams established except for the desirability of high surface area for the inducing jet.

2. The minimum cross-sectional area of the inducing jet determines the length of run before the high pressure air bottle is expended. Usually, the length, as well as the diameter, of a tube affects losses and therefore rate of flow and indirectly the length of time necessary

to empty a pressure vessel. However, in aspirator applications, tube lengths are short and velocities in the high velocity (inducing) jets are almost always sonic. Thus to a large extent cross-sectional area alone determines rate of flow. This simplified our experimentation with various sizes of jet outlets. But it was known that changes in cross-sectional area cause local cooling and heating approaching isentropic. The cooling causes frost formation on the outside of the aspirator. The frost could cause malfunction by freezing moving parts.

3. A further complicating factor was that the device must operate on a continually decreasing supply pressure resulting from the gradual depletion of the air supply. A pressure regulator on the supply bottle would make it possible to gain some advantage of constant pressure operation for the major part of the inflation period.

4. In aspirators, we discovered in early tests, because of the need for large entering air stream, there is a tendency for back-flow to exist as soon as a small pressure in the slide is achieved. The back flow we observed seemed to be concentrated in the center of the stream of air entering the slide. This reduces the effectiveness of the ram action mentioned above and often results in diverting the entire stream before satisfactory pressure has been attained in the slide.

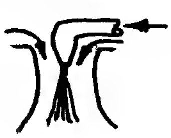
5. Overinflation, especially rupture of the slide, was considered a major hazard to be avoided by a positive feature of the design. Depletion of supply air as a means to avoid overinflation seemed too unpredictable to be safe.

Design development

Our first step in development was to experiment with the position and size of the high velocity jet with relation to size and shape of the main passage, or throat. Four configurations were tried on rough models using first the 150 psi shop air supply and then nitrogen from a 2000 psi bottle (nitrogen was readily available in rental high pressure cylinders).

The aspirators were fabricated from short pieces of standard pipe fittings, tubing, and available pieces of ordinary materials and hardware. For these tests, the trial aspirators were mounted in a 50 gallon oil drum. This permitted measuring developed pressure.

The most significant trial arrangements and the tentative results of each were:

Sketch	Arrangement	Results
	1. Small holes near the center directed radially through an annular slot.	Fair action but insufficient pressure developed.
	2. Single jet centered in a short venturi tube with short diffuser.	Tendency toward backflow with small back pressure.
	3. Several jets centered in a short venturi tube with short diffuser. (Similar to Exhibit 3)	Tendency toward backflow with small back pressure.
	4. Annular ring type of jet around the throat of a short venturi tube (giving a high velocity stream at the wall of the tube).	Best from standpoint of production of pressure in a slide.

The last type (No. 4) proved to show the greatest promise of total success in achieving all design objectives for the following reasons:

1. With refined design, more than ample pressure seemed assured.
2. Directing the jet along the walls of the venturi provided a maximum unobstructed passage for the inspired air.
3. The surface area of the jet is large.
4. The annular ring jet appeared to be quite original thus giving some assurance of proprietary rights and patentability.

From further experimentation with the annular ring design we established some preliminary size ratios for the jet width, throat diameter and diffuser proportions.

Enthusiastic over the results of our preliminary trials and anxious to demonstrate even limited success with a new principle, we quickly fabricated a more precise model which could be mounted in a slide. The general arrangement is shown in Exhibit 5. As a first approximation to the jet size we duplicated as nearly as possible the total area of the jets in one of the currently available aspirators.

The results, which were witnessed by Airslide management, were encouraging but indicated much work to be done. Pressure achieved was only 1.5 psi and inflation time about 15 seconds. The design of a suitable closing arrangement (door) for the main passage had not even begun.

But the results were considered good enough to justify a tentative decision that the final design would be based upon an annular ring jet. Consideration was then given to other features of the design as dictated by the desired performance. By this time nearly six months of part-time effort by Don and me had been expended.

Design configuration

In considering the mechanical features to be incorporated in the final aspirator, we decided that an attempt at near ideal operation was justified. Thus the following features were to be included in the design:

1. A positively actuated door (that is, one forced open by a high pressure piston rather than one pushed open by the air stream). This would make it possible to use a relatively stiff closing spring and thus simplify the problem of sealing the door.
2. Closing of the door and direct injection of bottle air when bottle pressure reached approximately 500 psi (that is, no injection of atmospheric air at this pressure and below). It was reasoned that this would give higher final inflation pressure.
3. Pressure regulator in the aspirator to provide constant pressure during passenger evacuation and to avoid overinflation.

We reasoned that in this type of equipment, cost and even weight of the final product are secondary to reliability and safety. This influenced our establishment of the above configuration. We decided to provide for positive action where possible, such as the door and the pressure regulator and hoped to be able to exceed the requirements of pressure and inflation time even though the product became more complicated, heavier and more expensive.

The first model

The selected design criteria resulted in a complicated design having several interior passages, valves, springs and a diaphragm. The design is shown in Exhibit 6. The operating cycle was intended to be:

1. Upon releasing the high pressure air, the door A is forced open by the piston B against the force of spring C.
2. The high pressure air passes through the annular ring jet D and draws in atmospheric air through the throat E.
3. When the bottle pressure declines to approximately 500 psi, spring C forces the door A to close. The seal is below the jet D.
4. The remaining air in the bottle is blocked by seal L and valve J.
5. Seal M prevents escape of air from the inflated slide.
6. Diaphragm F balanced by spring G senses the difference in pressure between the interior of the slide at H and the atmospheric pressure in the throat E.
7. The diaphragm operates valve J controlling air flow through passage K to maintain constant pressure in the slide.

An experimental model of this design was assembled and the various components tried under pressure. All components except the diaphragm and regulator valve arrangement gave satisfactory operation. We decided to concentrate our efforts on all components except the automatic pressure regulator and to withhold effort on that until other components were perfected. Investigation of a simple pressure relief valve to avoid overinflation was undertaken.

Tests with air bag

In the next series of tests we used an air bag simulating a slide so that it would be possible under nearly typical operating conditions to measure maximum obtainable inflation pressure, inflation time, and relative volumes of high pressure and atmospheric air.

For these tests the width of the jet, the diameters of the interior passages, the diameter of the throat, and the shapes of the entrance and exit passages were varied to gradually approach a best total arrangement. The model used was machined from pieces of solid aluminum and was arranged so that some pieces could be interchanged with others of different dimensions. The results of these tests and subsequent similar tests were the basis for design decisions reported on page 8.

It was learned in the course of these tests that an additional inner ring jet around the door piston gave even better results. So the piston B was redesigned to incorporate a change in diameter at the proper lengthwise position such that when fully open the gap between piston and cylinder provided a ring shaped jet. When the door was closed, an "O" ring seal prevented loss of high pressure air to the atmosphere (See Exhibit 7.)

Tests in an actual slide

Throughout the development period up to this point, occasional tests were run of experimental aspirators mounted in actual slides or test air bags. These gave valuable performance information to compare various proportions and arrangements. They related principally to the size of the high pressure jets, the shape of the door A and the size of the spring C. (See Exhibits 6 and 7.) In all of these tests, only the inflation time and the maximum pressure obtained were recorded.

Usually, some of the Airslide administrative staff was on hand to witness these tests. I recall one test which we thought was highly successful. We obtained a final slide pressure of over 2 psi and a time of under 10 seconds. Our joy was dampened, however, by the announcement that we would have to obtain 2¼ psi in 10 seconds to meet the anticipated

airline and Federal Aviation Administration requirements. By this time we had devoted over a year of development time and thought that we had nearly reached a full solution. So, we reluctantly planned more tests and investigation of refinements we could incorporate.

Further experimentation revealed that performance was improved if the passage to the inner jet and the piston could be closed off at a specific intermediate pressure. Therefore, a small spring-loaded piston-type valve was incorporated near the point of entry of the high pressure air to the valve. By proper selection of spring size, it was possible to pre-set this valve so that it would close off the passage to the inner jet and allow the door to close (See "O" on Exhibit 7.)

The lower end of the door was revised so that when the door closed, seal M (see Exhibits 6 and 7) closed against the wall of the throat at a point above the outer inducing jet. Thus when at 500 psi the piston "B" moved upward closing the door and inner jet, the remaining air in the bottle would flow directly into the slide through the outer jet.

The resulting design took the form of Exhibit 7. Operating cycle was:

1. Upon releasing the high pressure air, the valve N is forced open against the force of spring O.
2. The door A is forced open by the piston B against the force of spring C.
3. The high pressure air passes through inner jet P and outer jet D drawing in atmospheric air through the throat E.
4. When the bottle air declines to the predetermined value (500 psi), valve N closes the passage between the high pressure inlet and the piston B. Door A is closed by the action of spring C. Inner jet P is thereby also closed. Seal M closes leaving outer jet D open to the slide interior.
5. The remaining air in the bottle passes directly into the slide through jet D.
6. Maximum pressure in the slide is limited by a relief valve (not a part of the aspirator).

Tests with two-dimensional model

The most efficient shape of the mouth of the valve (inlet nozzle) and of the exit diffuser (see Exhibit 8) would be difficult to determine by tests of the kind we conducted to study the proportions and sizes of passages as explained above. To gain information as to the entrance and exit shapes, a two-dimensional model with transparent front face was constructed and tested with relatively low pressure supply air. For these tests, the performance parameter used as a basis for comparison was the entrainment ratio, $E = Q_2/Q_1$, where Q_1 = volume of primary (high pressure) air and Q_2 = volume of inspired (atmospheric) air. Both volumes were corrected to standard atmospheric pressure. This parameter was chosen because recognizing that the purpose of the valve is to fill an inflatable device, it was reasoned that the most effective flow through the valve would be mainly evidenced by a high entrainment ratio.

The tests revealed that the best combination of those tested was an abrupt bell-mouth entrance with a straight tube throat and exit. The bell-mouth tested was approximately three fourths of the throat diameter in length upstream from the jet location. The shape was a simple cone with a 90° apex angle and somewhat rounded edges (see Exhibit 8). The exit tube was a cylinder approximately two throat diameters in length below the jet.

But unexpected information was gained from these tests that proved to be more revealing and valuable than the results for which the tests were designed. In order to get a more clear idea as to what was happening in the throat, while the air was flowing through

the valve, we puffed cigarette smoke into the entrance. Doing this for several configurations revealed the pattern of the central back flow in the throat. This gave us a much better understanding of the relations between inducing jet size and location and throat size and configuration. We gained a better understanding of the action of the central jet; it tended to clear away the incipient back flow. We also noted that the shape which gave the best entrainment ratio showed the least tendency for back flow.

After nearly two years of effort

Having incorporated the cut-off valve in the top of the aspirator (N in Exhibit 7) and made minor revisions in general proportions of the jets and throat, we again ran a series of tests in an actual slide. Airslide personnel were on hand for some of these tests. We achieved inflations to 2¼ psi in less than 10 seconds. We felt that we had achieved full success. But we were informed that this was suitable for the present but in the future even higher pressures would be required. This was somewhat discouraging, but we were confident that our aspirator could do better with even further refinement.

One such refinement was a pressure regulating device in the high pressure line. It was known that a simple orifice in the line would serve as a pressure reducer and give some of the advantages of a pressure regulator. We quickly designed an arrangement to place, on a trial basis, several sizes of orifices in the high pressure passage at the entrance to the valve. The results were encouraging, but not as effective as a proper regulating valve. The difficulty faced was that the regulating valve would add weight to the complete unit. Also it was discovered that a regulator fully suitable for this application was not to be found on the market.

Status at this point

The results of the tests up to this time provided the basis for design decisions as follows:

1. Throat diameter was to be 2 inches.
2. Outer jet width was to be 0.007 inches.
3. Inner jet width was to be 0.005 inches.
4. High pressure air to inner jet and piston was to cut off at 500 psi.
5. A pressure regulating or reducing device of some kind was to be used in the high pressure line to the valve.
6. Aspirator entrance was to be shaped as shown approximately in Exhibit 8. Choice of exit shape was limited by door arrangement and overall aspirator size and proportions.
7. Inflation time must not be more than 10 seconds.
8. Inflation pressure should be near 2½ psi.
9. Air bottle size must be not larger than 300 cubic inches.
10. Slide volume would be at least 60 cubic feet.
11. General arrangement and shape would be as shown in Exhibit 7.

Total performance tests

To establish further the total performance of the valve as a complete unit, a more comprehensive test set-up was constructed. The test equipment consisted of (1) a typical aircraft slide, (2) a standard air bottle of the type and size to be used with that slide, (3) the trigger-release valve on the bottle which was being used with existing slides and (4) a selection of

pressure regulators and reducers for the high pressure air line. The following information was recorded with a movie camera used to record a special panel of instruments: pressure at the air bottle, pressure in the valve interior high pressure passage, pressure in the slide, time, and degree of inflation of the slide (judged from appearance in the background of the picture).

Numerous tests were run with various combinations of pressure regulating devices and with several sizes of springs at C and O (Exhibit 7). The results of one of these tests are shown in Exhibit 9.

The performance using the best available pressure reducer was found to be only slightly better than that with a simple orifice in the inlet. Both gave inflation time and pressure within the limits set forth in the design specifications.

Some thought was given to the possibility of developing a suitable pressure regulator. However, it was learned that a company which had been making a line of regulators would be interested in working with prospective aspirator users to develop a regulator specifically for the purpose.

We decided to "freeze" the design at this point and discontinue tests.

Patent application

During the latter part of the development, a patent attorney was kept informed of major advances in the design. At the proper time, he instituted a patent search, arranged to have proper drawings made and prepared the patent application. The result was Patent No. 3338266 shown as Exhibit 10.

Further development

I decided at this time to discontinue manufacturing and to devote my efforts to engineering consulting. Don, having gained much experience related to all of the products of Airslide Corporation, was asked to join them and to continue with aspirator development.

The patent, designs, test data and three prototype aspirators were sold to Airslide Corporation. The development continued under the direct sponsorship of the new owner.

Research into alternate methods of providing for the rapid opening of the main door and for suitably sealing it when closed led Don to the conclusion that it is not necessary to provide for opening the door by means of the high pressure piston arrangement. After a lengthy and thorough search, a suitable material was selected from which he could fabricate a flexible folding door. This material could be used to form a door which is flexible enough to be easily opened by the force of the main stream of inspired air and yet is strong enough to form a tight seal when the door is closed. The design of the door is shown in Exhibit 11. The new door design replaced the comparatively heavy poppet type door and made it possible to eliminate the large spring. The design is simpler and considerably lighter.

To improve the effectiveness in producing pressure in the inflated slide, a long diffuser was added to the throat. These changes resulted in proportions resembling a long slim cylinder instead of the shorter broader shape of the earlier model. The annular shaped inner jet was replaced by two small round jets (A in Exhibit 11) located in a cross tube at the entrance. The valve in the original cross tube was also eliminated because eliminating the piston for the door made the valve unnecessary. This design, shown in Exhibit 11, is the one now being mounted in slides manufactured by Airslide Corporation.

In a recent discussion with Don, I learned that the rise in required pressure at full inflation and the reduction in the inflation time are continuing. He is attempting to achieve about 3 psi pressure in about six to eight seconds with some new aspirators he is working on. He is also working on a new version of the release valve which is mounted on the high pressure air bottle. This new valve will contain a built-in pressure regulator.

This regulator, it is hoped, will provide a rising pressure curve such that as the slide nears full inflation, the supply air to the aspirator will be at higher pressure than it was at the start of inflation. This tends to provide a better compromise among entrainment ratio, inflation time, and inflation pressure. Our experience taught us that a relatively large diameter, clear, short throat gives best entrainment and shortest time but lower inflation pressure, whereas the opposite is true for a smaller longer throat. The rising supply pressure tends to counteract the lower inflation pressure which accompanies rapid inflation by giving a final surge of high velocity air when most needed to boost the pressure in the fully inflated slide. We had achieved this effect in the Band Company final model by the less efficient method of direct injection of the last portion of the air in the supply bottle.

EXHIBITS, ECL 121

Exhibit 1	Copy of typical instruction card for use of emergency escape slide
Exhibit 2	General arrangement of slide, aspirator, and air bottle near the airplane door
Exhibit 3	Patent No. 2,866,593
Exhibit 4	Patent No. 2,772,829
Exhibit 5	Sketch of working model of annular ring jet used to determine first approximations to sizes and proportions
Exhibit 6	Sketch of first Band Co. experimental aspirator
Exhibit 7	Sketch of Band Co. final aspirator design
Exhibit 8	Proportions of aspirator throat determined from laboratory test of two dimensional model with relatively low pressure supply air
Exhibit 9	Slide pressure curves
Exhibit 10	Patent No. 3,338,266
Exhibit 11	Sketch of final Airslide Corp. design aspirator

B-727

ECL 121

FOR YOUR SAFETY. Know how to move out of this airplane fast. There is fire-danger any time a landing is other than normal—particularly when the airplane structure is damaged.

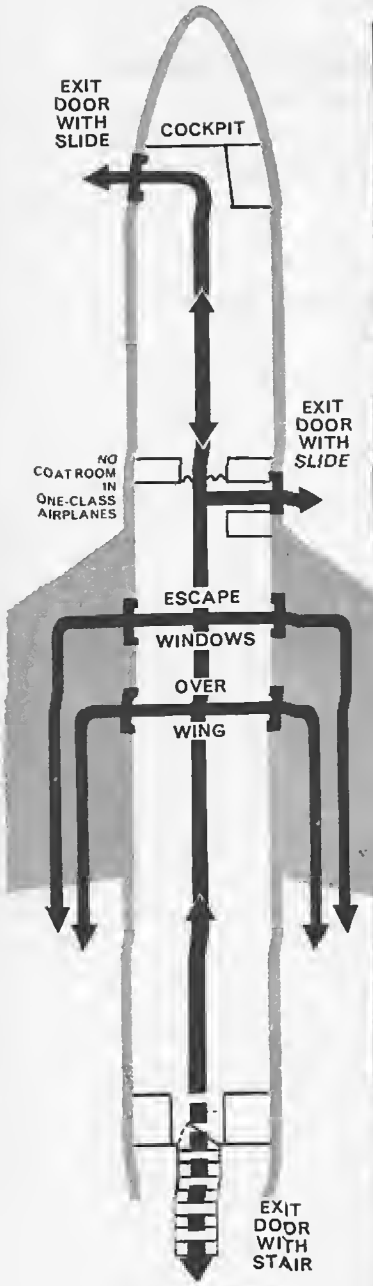
Below is a floor plan of the plane you are in. Familiarize yourself with the location of the exits. Note particularly the exits nearest you. Study how they are opened and also the protective position you should assume during an emergency landing. When leaving, move to the exits immediately. Do not go back for coats, purses, or other personal items.

A WORD ABOUT YOUR SEAT BELT—Rough air (turbulence) at high altitudes, although infrequent, can be severe. When the seat belt sign is lighted in-flight, please comply with the sign to prevent possible injury. Seasoned air travelers usually leave their seat belts fastened all the time and pull them up snug whenever the seat belt sign is lighted.

HOW TO OPEN EXITS

CA 319 REV. 9-67 PRINTED IN U.S.A.

UNITED

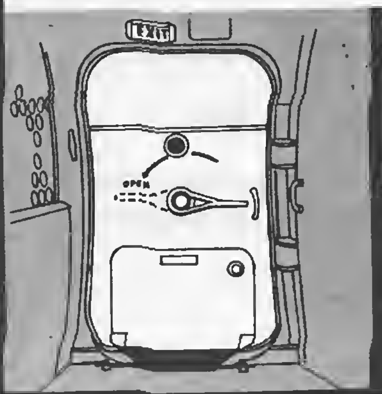


(may not be useable)

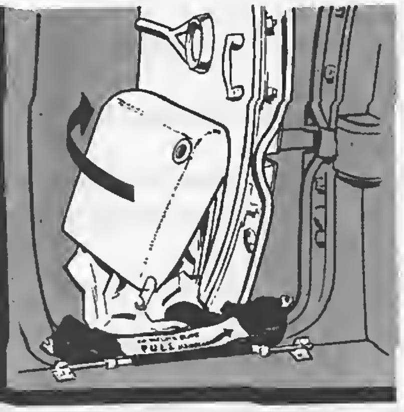
SEE OTHER SIDE

DOOR EXITS AND ESCAPE SLIDES

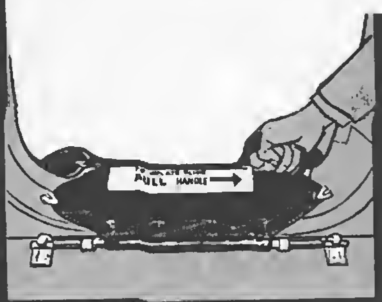
1. Lift handle up and over.



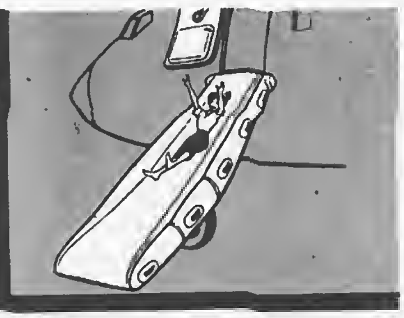
2. Push out on door.



3. Pull RED handle to inflate slide.

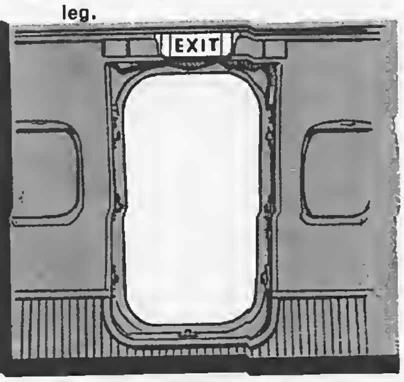


4. Jump and sit in slide.



ESCAPE WINDOWS OVER WINGS

1. *Pull cover open.*
2. Grasp RED handle and pull inward and down.
3. *Entire window is then discarded.*
4. Exit through window—leg, body, leg.



FEDERAL AIR REGULATIONS REQUIRE YOUR SEAT BACK TO BE UPRIGHT DURING TAXI, TAKE-OFF AND LANDING.

EXHIBIT 1 -- Copy of Typical Instruction Card for Use of Emergency Escape Slide

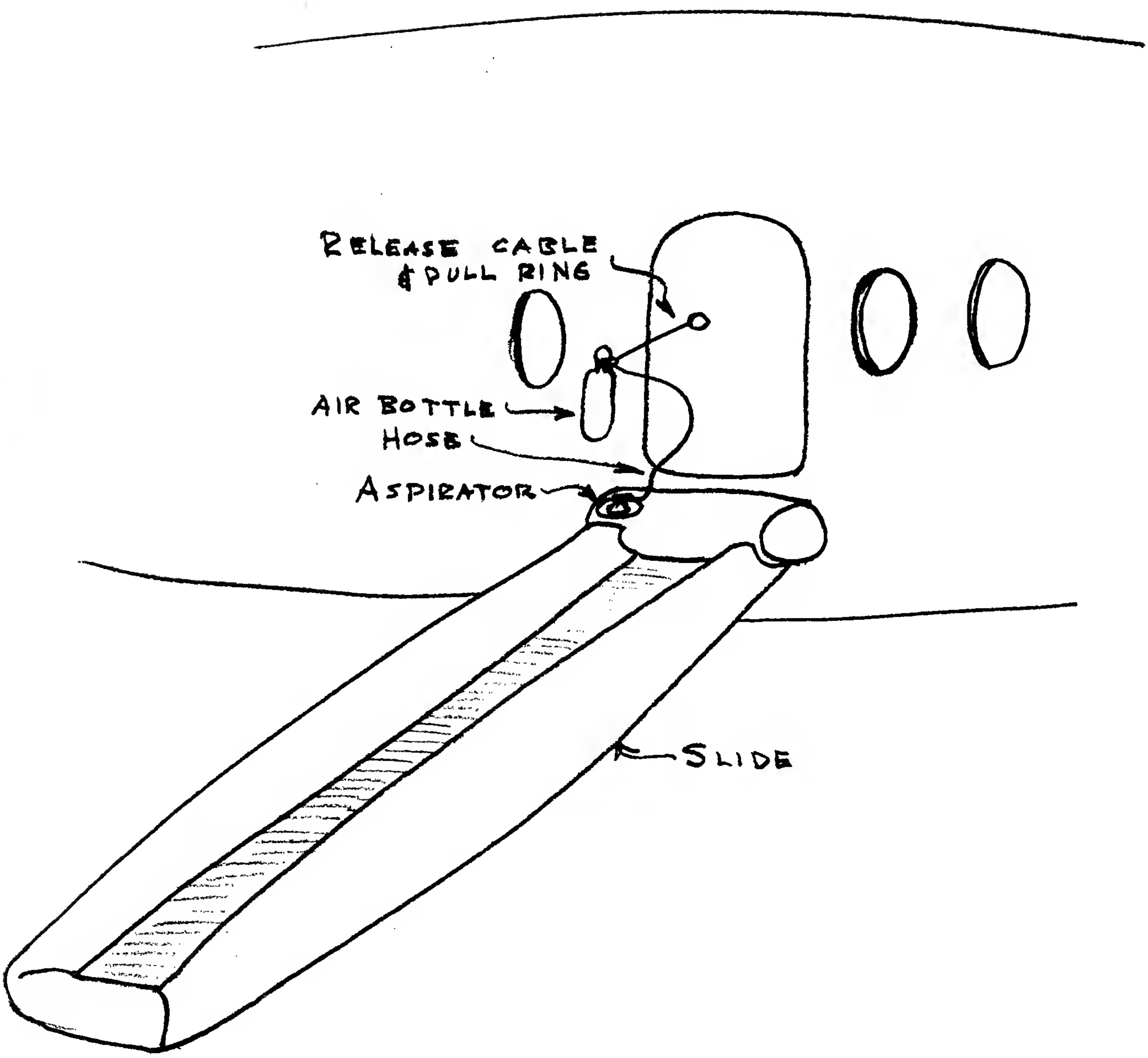


EXHIBIT 2 – General Arrangement of Slide, Aspirator and Air Bottle Near the Airplane Door

ECL 121

Dec. 30, 1958 **2,866,593**

ASPIRATING APPARATUS

Filed Jan. 28, 1954 4 Sheets-Sheet 1

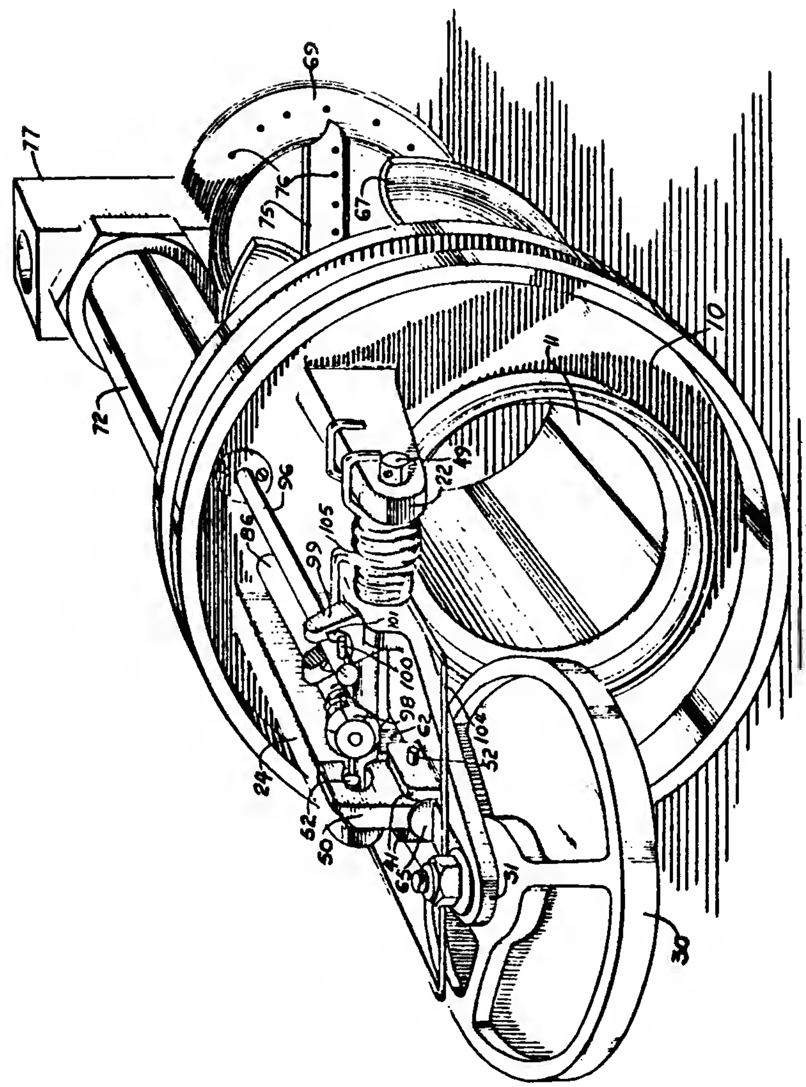


Fig. 1

Dec. 30, 1958 2,866,593

ASPIRATING APPARATUS

Filed Jan. 28, 1954 4 Sheets-Sheet 2

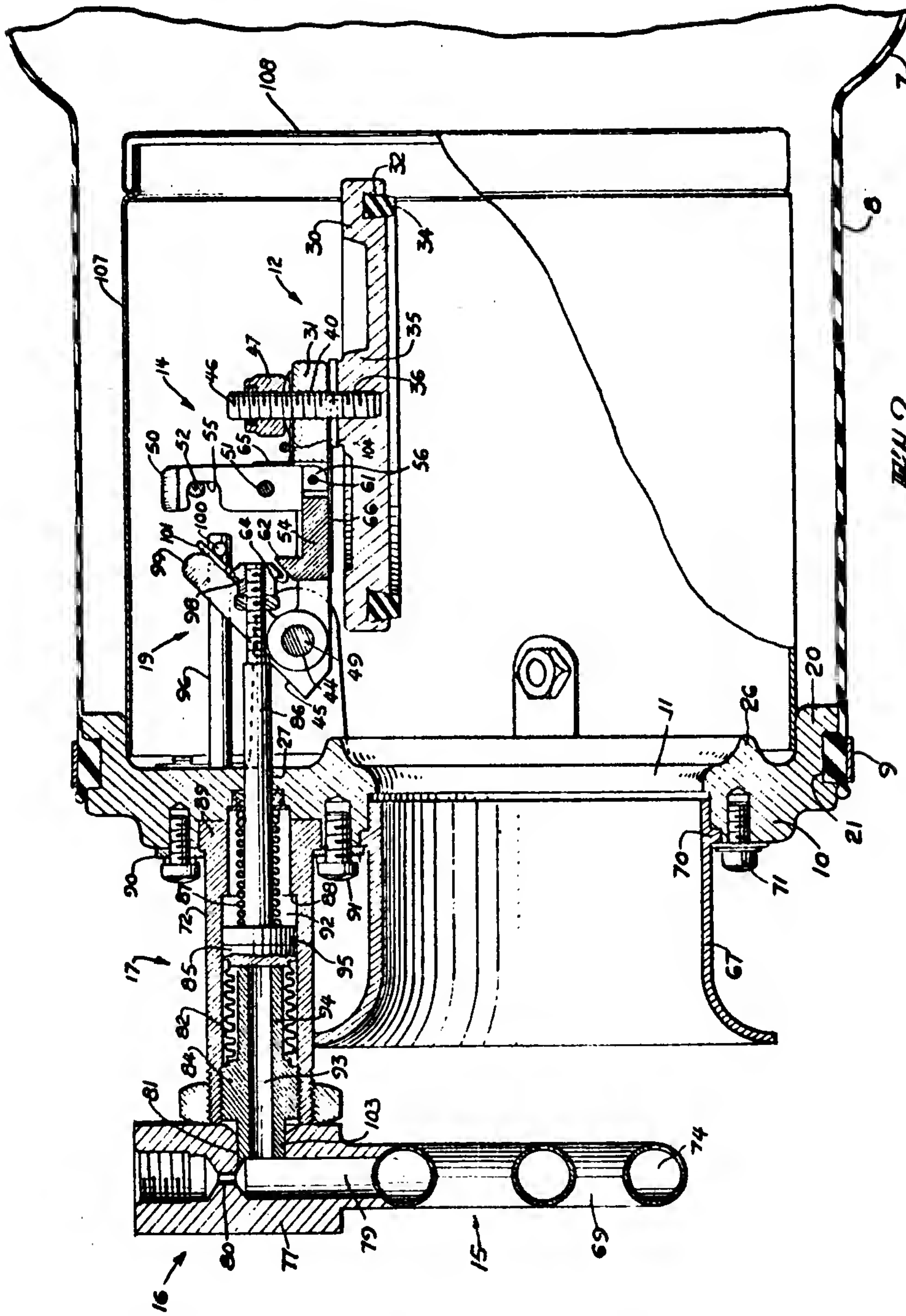


FIG. 2

Dec. 30, 1958

2,866,593

ASPIRATING APPARATUS

Filed Jan. 28, 1954

4 Sheets-Sheet 3

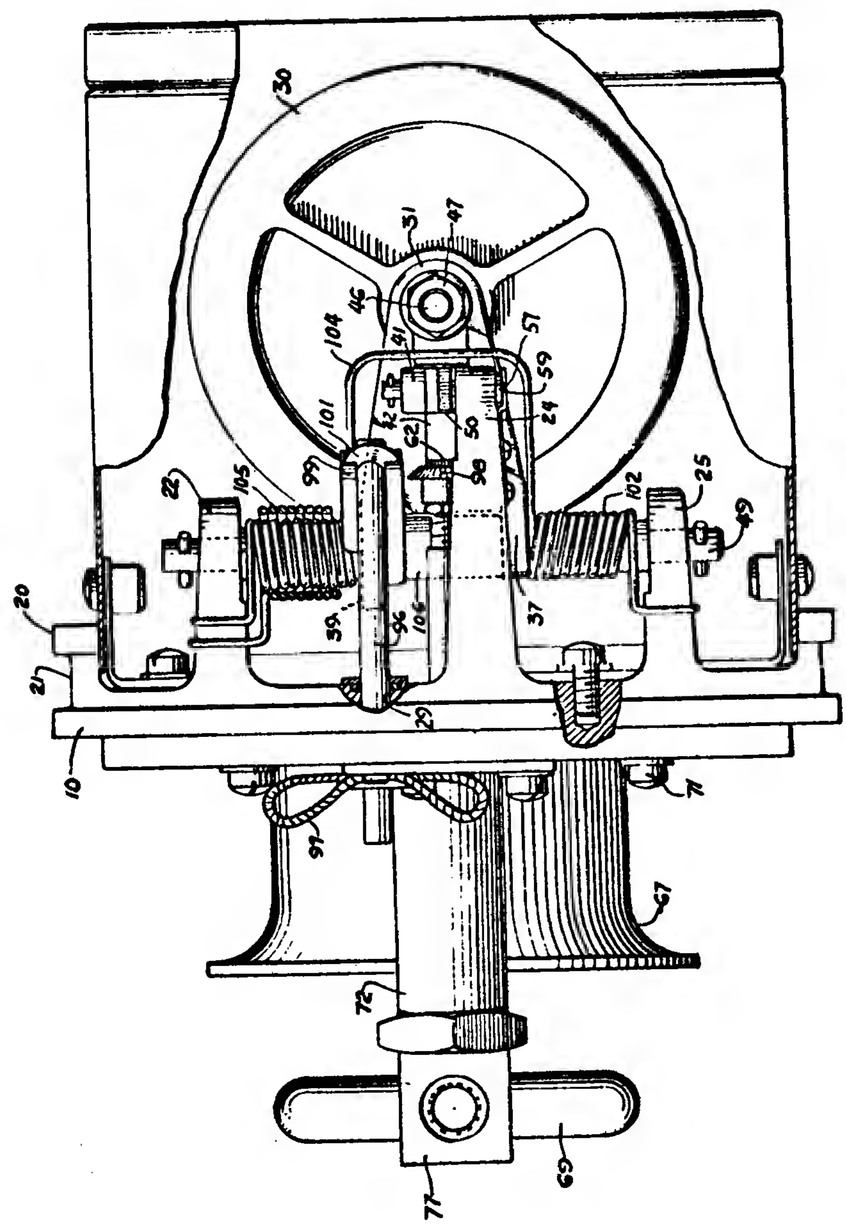


Fig. 3

EXHIBIT 3, Continued
Patent No. 2,866,593

Dec. 30, 1958 2,866,593

ASPIRATING APPARATUS

Filed Jan. 28, 1954 4 Sheets-Sheet 4

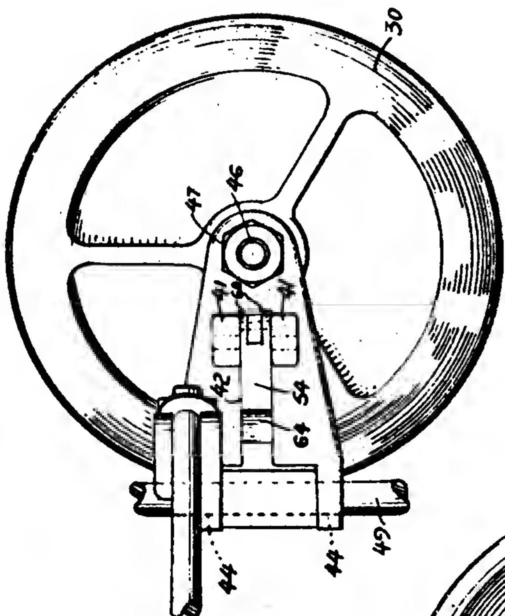


Fig. 5.

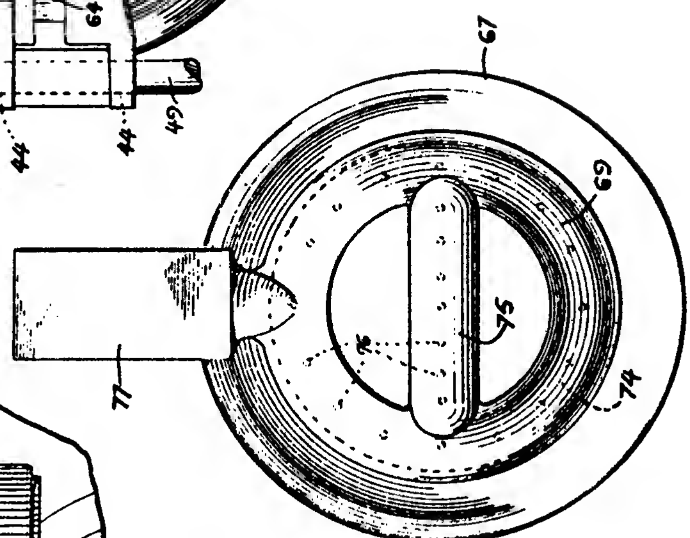


Fig. 6.

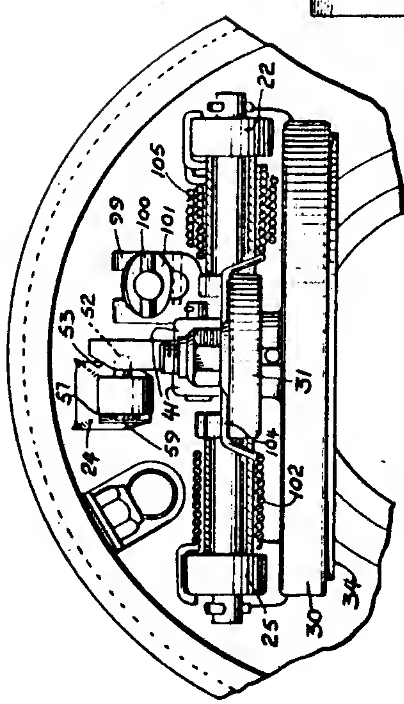


Fig. 4.

United States Patent Office

2,866,593

Patented Dec. 30, 1958

2,866,593

ASPIRATING APPARATUS

Application January 28, 1954, Serial No. 406,822

26 Claims. (Cl. 230—95)

This invention relates to inflation apparatus, and, more particularly, to aspirating apparatus for the inflation of flotation equipment such as collapsible boats, pack rafts and similar devices.

Such inflatable devices are normally maintained in collapsed, folded condition, for purposes of saving space, until it is desired to put them to use, at which time compressed air, or other gas, is admitted into the devices to inflate them. In order to effect a reduction in bulk and weight of the gas supplying apparatus, the use of aspirating apparatus has been proposed which utilizes a minimum quantity of compressed gas to aspirate a volume of ambient atmospheric air into the inflatable device.

Such aspirating apparatus included various valving mechanisms, such as spring biased check valves or piston operated valves, which depended for their operation upon utilization of a portion of the kinetic energy of the compressed gas or of the aspirated ambient air. Additional disadvantages of the proposed apparatus included a complexity of passageways for both the compressed gas and the ambient air, which passageways caused the gas and air to undergo several changes of direction and generally provided numerous flow restricting features. Each time the gas or air was required to open a valve, change direction, or do other work, there occurred losses of kinetic energy which seriously limited the efficiency and air-to-gas ratio of such apparatus.

Accordingly, an object of the present invention is to provide simple, economical and practical aspirating apparatus which overcomes the foregoing disadvantages.

Another object is to provide such apparatus which is highly efficient and capable of producing a high air-to-gas ratio.

A further object is to provide such apparatus wherein the kinetic energy of the gas and air is employed almost entirely for inflation purposes.

Other and further objects of the invention will be obvious upon an understanding of the illustrative embodiment about to be described, or will be indicated in the appended claims, and various advantages not referred to herein will occur to one skilled in the art upon employment of the invention in practice.

In accordance with the invention, the foregoing objects generally are accomplished by providing aspirating apparatus comprising, in combination, a body portion formed with an opening; closure means adapted to close the opening; aspirating means adjacent the opening; means for supplying gas under pressure to the aspirating means; means for urging the closure means to close the opening; means for normally retaining the closure means open; pressure sensitive means associated with the gas supplying means adapted to render the last mentioned means ineffective and the closure urging means effective when the gas is at a predetermined pressure; and manually controlled reset means adapted to render the closure urging means ineffective and the closure retaining means effective. The aspirating means includes a member adjacently

spaced from the opening having a passageway provided with a plurality of apertures arranged to direct gas under pressure into the opening.

A preferred embodiment of the invention has been chosen for purposes of illustration and description, and is shown in the accompanying drawings, forming a part of the specification, wherein:

Fig. 1 is a fragmentary perspective view of aspirator apparatus in accordance with the invention.

Fig. 2 is a longitudinal sectional view of the apparatus shown in Fig. 1 with a portion of an inflatable device secured thereto.

Fig. 3 is a plan view of the apparatus with portions thereof broken away to more clearly illustrate the closure means.

Fig. 4 is a fragmentary end view of the closure means.

Fig. 5 is a fragmentary plan view of the closure means with some of the elements removed to illustrate features of the closure means, retaining means and reset means.

Fig. 6 is an elevational view illustrating features of the aspirating means.

Referring to the drawings in detail and more particularly to Figs. 1 to 3 thereof, there is shown a portion of an inflatable bag 7 having a neck 8 secured to the aspirating apparatus (Fig. 2). This apparatus, in general, comprises a body portion 10 formed with an opening 11, closure means 12 adapted to close the opening; a latch assembly 14 for normally retaining the closure means open; aspirating means 15 adjacent the opening; conduit means 16 adapted for connection to a source of gas under pressure (not shown) for supplying the gas to the aspirating means; and pressure sensitive means 17 adapted to render the latch assembly ineffective when the gas is at a predetermined pressure. Reset means 19 is also provided in order that the closure means may be returned to its original position, as shown.

The body portion 10 is a circular member having the opening 11 offset with respect to the center thereof and is formed with a cylindrical flange 20 at its periphery having an annular groove 21 for mounting therein the neck 8 of the bag 7, in a suitable manner, as by a metal strap 9. Three projections, 22, 24 and 25 (Fig. 3) are formed on the body portion at the side facing the bag 7, above the opening 11, which serve as mounts for elements of the apparatus to be described, and an annular lip 26 is formed on the side of the body portion facing the bag 7 which surrounds the opening and is adapted to serve as a seat for the closure means 12. The body portion is also provided with a pair of bores 27 and 29 (Figs. 2 and 3) extending therethrough above the opening 11, as viewed.

The closure means 12 comprises a circular door 30 and a hinge 31. The door 30 is formed with an annular groove 32 on one side thereof in which an annular rubber gasket 34 is arranged for seating on the lip 26 on the body portion to seal the opening 11. A central hub 35 is provided on the opposite side of the door and is formed with an internally threaded centrally located recess 36.

The hinge 31 is generally triangular shaped and is formed with a pair of legs 37 and 39 (Fig. 3), extending from the ends of the base, and a bore 40 therethrough adjacent the apex thereof. A pair of tabs 41 project upwardly from the hinge and a slot 42 extends from the base thereof towards the apex and passes between the tabs 41 (Fig. 5). The legs 37 and 39 are each provided, at their extremities, with a horizontal bore 44 extending therethrough. The leg 39 extends beyond its bore 44 and is provided with a flat inclined surface 45 for a purpose which will be described hereinafter.

The door and hinge are secured together by inserting a threaded pin 46 through the bore 40 in the hinge, screw threading one end thereof into the threaded recess 36 of

the door hub and securing a lock nut 47 to the other end of the pin. A suitable spring washer may be used between the door and the hinge.

A pin 49, journalled at its ends in suitable bores formed in the projections 22 and 25, passes through the bores 44 in the legs 37 and 39 of the hinge, wherefore the hinge is mounted thereon for pivotal movement thereabout.

The latch assembly 14 comprises a latch member 50 pivotally mounted on a pin 51 extending therethrough and supported at its ends in the tabs 41 projecting upwardly from the hinge 31, a keeper 52 mounted in the projection 24 extending outwardly from the body portion 10, and a trigger 54 pivotally connected to the latch member.

The latch member is provided with a notch 55 at its upper end and with an extension 56 of reduced width and thickness at its lower end, which extension projects into the slot 42 of the hinge. The surface 53 of one side of the latch member is tapered inwardly and upwardly, as shown in Fig. 4.

The keeper 52 is cylindrical in shape and extends through a bore in the end of the projection 24, for engagement with the notch 55 of the latch member, and is provided with a flange 57 at one end thereof. A flat spring 59 mounted on the projection urges the keeper in a direction towards the latch member.

The trigger 54 fits into the slot 42 of the hinge and is axially slotted at one end to form a pair of prongs 60, as shown in Fig. 5, each of which extends adjacent one side of the extension 56 of the latch member. Similar bores through the prongs 60 and the extension 56 provide a passageway for a pin 61 (Fig. 2), wherefore the hinge and the trigger are connected for pivotal motion with respect to each other. The other end of the trigger is formed with a projection 62 which extends upwardly out of the slot 42 in the hinge and has an inclined surface 64 at its outer end for a purpose to be described hereinafter.

A flat spring 65 is mounted in the end of the slot 42 of the hinge 31 and extends upwardly abutting the back of the latch member 50 while a second flat spring 66 is secured to the bottom surface of the hinge and abuts the bottom of the trigger 54, the purpose of both of which will be described hereinafter.

As illustrated in Figs. 1 to 3 and 6, the aspirating means 15 comprises a cylindrical tube 67, extending from the opening 11 outwardly in a direction away from the lip 26, and a nozzle 69. The tube has an annular flange 70 extending radially outwardly thereof adjacent the body portion 10 and is flared at its opposite end. The flange is secured to the body portion by overlapping washers held down by bolts 71 and 91.

The nozzle 69 is mounted at the end of, and perpendicular to, a tubular member 72 which, in turn, is secured, at one end thereof, to the body portion adjacently above, and parallel to, the tube 67 so that the nozzle 69 is located directly in front of, but spaced from, the flared end of the tube 67. The nozzle is an annular or torus-shaped member having a passageway 74 provided with a plurality of radially disposed apertures 76 arranged to direct gas under pressure through the tube 67 and the opening 11 (Figs. 1 and 5). In the preferred embodiment of the invention, the apertures 76 in the annular or torus-shaped member lie in a circle, the diameter of which is no greater than the minimum inside diameter of the tube 67.

In order to maintain a high efficiency in larger size units, in which turbulence in the tube 67 may cause a portion of the air and gas to reverse its direction and escape through the center of the nozzle, a second member 75, provided with a plurality of apertures similar to those in the annular member, may be radially disposed within the annular member.

The conduit means 16 for supplying gas under pressure to the aspirating means includes a block 77 which is provided with a longitudinal bore 79 threaded at one end for connection to a conduit or gas supply line and is formed with a portion of reduced diameter to provide a pressure reducing orifice 80. A second bore 81 extends perpendicular to, and communicates with, the bore 79 on the downstream side of the orifice 80. The block 77 is integrally connected to the nozzle 69, serving to support the same, and the bore 79 communicates with the annular passageway 74, downstream of the orifice 80, to serve as an inlet for the nozzle.

The pressure sensitive means 17 includes the tubular member 72 which serves as a housing for an expansible bellows 82, a retainer member 84 for the bellows, a cap 85 at one end of the bellows, a shaft 86 and a spring 87.

The tubular member 72 is formed with an external annular flange 89 at one end thereof which fits into a recessed portion of the body portion 10. An annular retainer ring 90 fits around the member 72 and overlaps the flange 89 and the body portion 10 for securement thereto by bolts 91. The member 72 has a longitudinal stepped bore 92 extending therethrough providing a shoulder 88; and the retainer member 84 is secured into the end thereof away from the body portion.

The retainer member 84 is formed with a cylindrical projection 94 extending longitudinally into the bore 92 and with a second cylindrical projection 103 secured in the bore 81. A bore 93 extends through the projections 94 and 103 for a purpose to be described hereinafter.

The bellows 82 is disposed within the bore 92 of the tubular member 72 and encompasses the extension 94 of the retainer member 84, being secured, at one end, to the retainer member and at the other end to the cap 85 which normally abuts the end of the retainer member extension 94 and is longitudinally slidable in the bore 92.

The shaft 86 extends through the bore 27 in the body portion and is formed with a flange 95 at one end thereof abutting the cap 85. The other end of the shaft is of reduced diameter and is threaded for engagement with a trigger catch 98 having a beveled flange for a purpose to be described. A lock nut may be threaded onto the shaft in back of the catch 98 to lock the same in the desired position.

The spring 87 is located in the bore 92 and bears against the flange 95 at one end and against the face of the body portion 10 at the other end to urge the shaft in a direction towards the retainer member 84.

The reset means 19 comprises a rod 96 slidably mounted in the bore 29 in the body portion 10, a suitable manual grip, such as a steel cable loop 97 secured to one end of the rod, and a generally U-shaped reset lever 99 which has one arm thereof extending below the base of the U. The extended portion is provided with a bore therethrough by which it is pivotally mounted on the pin 49, adjacent the leg 39 of the hinge, and between the legs 37 and 39 thereof, and a spacer 106 is provided on the pin 49 between the leg 37 and the extended arm of the reset lever 99 to maintain the lever adjacent the leg 39 of the hinge.

The rod 96 extends between the arms of the lever 99 and a pin 100 (Figs. 2 and 4) in the end of the shaft retains a washer 101 loosely on the shaft adjacent the arms of the reset lever. The washer has an outside diameter larger than the distance between the arms for a purpose to be described hereinafter.

A torsion spring 102 is coiled about the pin 49 adjacent each of its ends and has a center portion 104 which extends away from the pin and abuts the upper surface of the hinge adjacent the nut 47 and urges the same in a downward direction, as viewed, to close the door 30.

A second torsion spring 105 is superimposed over one end of the spring 102 and bears against one surface of the reset lever 99 to urge the same into the position shown.

If desired, a cylindrical shield 107 may be secured to

the flange 20 of the body portion to provide protection for the closure and reset means and a screen 108 (Fig. 2) may be provided at the outer end of the shield to keep foreign matter out of the inflatable article.

In operation, the aspirating apparatus is connected to the inflatable bag 7, or other flotation equipment as shown, and the pressurized gas supply line is connected to the bore 79 of the block 77. In its normal condition, prior to use, the apparatus is set in the position shown, with the closure means latched open.

When it is desired to inflate the bag, gas under pressure is admitted to the bore 79 of the block 77 and undergoes a pressure drop as it passes through the orifice 80. The gas then flows, at high velocity, into the nozzle 69 and into the bore 93 of the retainer member 84.

As the gas under pressure enters the bore 93, it acts against the face of the cap 85, urging the same to move in the bore 92 of the tubular member 72, in a direction away from the retainer member, thereby enabling the gas to fill and expand the bellows 82. Movement of the cap 85 causes the shaft 86 to move longitudinally in the same direction, against the action of the spring 87, until the flange 95 abuts the shoulder 88. Such motion of the shaft causes the beveled flange of the trigger catch 98 to contact the inclined surface 64 of the projection 62 on the trigger 54 and to cause the trigger to pivot downwardly about the pin 61 against the action of the flat spring 66 until the flange of the catch 98 passes beyond the projection 62. At this point, the motion of the shaft is stopped by the shoulder 88 and the spring 66 returns the trigger to its normal position with the flange portion of the catch on the side of the projection 62 towards the latch member 50.

Simultaneously, the gas entering the passageway 74 of the nozzle 69 and the passageway of member 75, is directed in jet like, parallel streams out through the spaced apertures 76 through the tube 67. The gas, passing through the tube in such manner, aspirates a large volume of ambient air at a relatively low pressure through the tube and into the bag 7 to inflate the bag.

Inflation continues until the supply pressure begins to drop, whereupon the pressure in the bellows 82 also drops, allowing the bellows to contract. The spring 87 urges the shaft 86 in a direction away from the shoulder 88. This motion continues until the flat face of the trigger catch flanges engages the flat face of the trigger projection 62 and, at a predetermined pressure, draws the trigger in a longitudinal plane towards the body portion. The trigger, being pivotally connected to the latch member 50, as described, causes the same to rock about the pin 51, against the action of the flat spring 65, until the notch 55 disengages the keeper 52 permitting the center portion 104 of the torsion spring 102 to pivot the hinge 31 downwardly about the pin 49 so that the door 30 closes the opening 11 and the gasket 34 comes to rest in sealing engagement with the lip 26 of the body portion, thereby trapping the pressurized and aspirated fluid in the inflated bag. As soon as the latch member and keeper are disengaged, the flat spring 65 causes the former to return to its original position with respect to the hinge 31.

The pressure at which the door will close the opening 11 may be varied by adjusting the position of the trigger catch 98 on the end of the shaft 86. As the catch, and its lock nut, is threaded further onto the shaft, it will engage the trigger projection 62 sooner, as the supply pressure drops, to unlatch the door.

When the hinge comes to rest in door closing position, the inclined surface 45 on the leg 39 thereof, having pivoted 90° about the pin 49, abuts the upper inclined surface of the base of the U-shaped reset lever 99.

To reset the apparatus, the cable loop 97, fixed to one end of the rod 96, is grasped and drawn in a direction away from the body portion 10, causing the rod, the pin 100 and the washer 101, to move longitudinally in the same direction. Such movement causes the washer to bear against the arms of the reset lever 99 whereby the reset lever rocks pivotally about the pin 49 and, in turn, bears against the inclined surface 45 of the hinge leg 39 to pivot the same, as well as the latch assembly 14 and the door 30, about the pin 49 to move the door in a 90° arc away from the opening 11 in the body portion against the action of the spring 102, until the latch engages the keeper. As the cable loop is released, the spring 105 returns the reset lever, as well as the rod 96, to the position shown.

As best illustrated in Fig. 4, latching occurs when, as the latch assembly is pivoting away from door closing position, the surface 53 of the latch member engages the keeper 52 urging the same to the left, as viewed, against the action of the flat spring 59, until the notch 55 is opposite the keeper, at which point the keeper is urged by the spring 59 into the notch to retain the latch member. The flange 57, at one end of the keeper, abuts the projection 24 and prevents the keeper from moving out of the bore in which it is mounted.

Resetting of the apparatus completes a cycle of operation and prepares the apparatus for subsequent use.

From the foregoing description, it will be seen that the present invention provides an improved, highly efficient aspirating apparatus which is simple, economical and practical and which is capable of producing a relatively high air-to-gas ratio. It will further be seen that apparatus according to the present invention utilizes the kinetic energy of the gas and air almost entirely for inflation purposes.

While the apparatus in accordance with the present invention has been described in connection with inflating flotation equipment by way of illustration, it will be understood that such apparatus is suitable for any other use where it is desired to admix air with the aspirating fluid and introduce the mixture thereof into an enclosure or confined zone.

As various changes may be made in the form, construction and arrangement of the parts herein, without departing from the spirit and scope of the invention and without sacrificing any of its advantages, it is to be understood that all matter herein is to be interpreted as illustrative and not in any limiting sense.

We claim:

1. Aspirating apparatus comprising, in combination, a body portion formed wtih an opening, closure means mounted on said body portion for closing said opening, aspirating means positioned adjacent said opening for directing gas under pressure through said opening, means supported by said body portion for supplying gas under pressure to said aspirating means, means on said body portion for normally retaining said closure means open, and pressure sensitive means in fluid flow communication with said gas supplying means and operatively engaging said retaining means to render said retaining means ineffective when said gas is at a predetermined pressure.

2. Aspirating apparatus comprising, in combination, a body portion formed with an opening, closure means mounted on said body portion for sealing said opening, means mounted on said body portion for urging said closure means to seal said opening, aspirating means positioned adjacent said opening for directing gas under pressure through said opening, means supported by said body portion for supplying gas under pressure to said aspirating means, means on said body portion for normally retaining said closure means open, and pressure sensitive means in fluid flow communication with said gas supplying means and operatively engaging said retaining means to render said retaining means ineffective when said gas is at a predetermined pressure.

3. Aspirating apparatus comprising, in combination, a body portion formed with an opening, closure means mounted on said body portion for sealing said opening,

aspirating means positioned adjacent said opening for directing gas under pressure through said opening, means supported by said body portion for supplying gas under pressure to said aspirating means, latch means mounted on said closure means for normally retaining said closure means open, and pressure sensitive means in fluid flow communication with said gas supplying means and operatively engaging said latch means to render said latch means ineffective when said gas is at a predetermined pressure.

4. Aspirating apparatus comprising, in combination, a body portion formed with an opening, closure means mounted on said body portion for sealing said opening, means mounted on said body portion for urging said closure means to seal said opening, aspirating means positioned adjacent said opening for directing gas under pressure through said opening, means supported by said body portion for supplying gas under pressure to said aspirating means, keeper means on said body portion, a latch member mounted on said closure means adapted to engage said keeper means to retain said closure means open, and pressure sensitive means in fluid flow communication with said gas supplying means and operatively engaging said latch member to render said latch member ineffective and said closure urging means effective when said gas is at a predetermined pressure.

5. Aspirating apparatus comprising, in combination, a hody portion formed wtih an opening, closure means mounted on said body portion for sealing said opening, aspirating means positioned adjacent said opening for directing gas under pressure through said opening, means supported by said body portion for supplying gas under pressure to said aspirating means, means on said body portion for normally retaining said closure means open, release means on said closure means operatively engaging said retaining means to render the same ineffective, and pressure sensitive means in fluid flow communication with said gas supplying means and operatively engaging said release means to render said release means effective when said gas is at a predetermined pressure.

6. Aspirating apparatus comprising, in combination, a body portion formed with an opening, closure means mounted on said body portion for sealing said opening, means mounted on said body portion for urging said closure means to seal said opening, aspirating means positioned adjacent said opening for directing gas under pressure through said opening, means supported by said body portion for supplying gas under pressure to said aspirating means, latch means for normally retaining said closure means open, a trigger connected to said latch means for rendering said latch means ineffective, and pressure sensitive means in fluid flow communication with said gas supplying means and engaging said trigger to render said trigger effective when said gas is at a predetermined pressure.

7. Aspirating apparatus comprising, in combination, a body portion formed with an opening, closure means mounted on said body portion for sealing said opening, means mounted on said body portion for urging said closure means to seal said opening, aspirating means positioned adjacent said opening for directing gas under pressure through said opening, means supported by said body portion for supplying gas under pressure to said aspirating means, keeper means on said body portion, a latch member pivotally mounted on said closure means adapted to engage said keeper means to retain said closure means open, a trigger connected to said latch means for rendering said latch member ineffective, and pressure sensitive means in fluid flow communication with said gas supplying means and engaging said trigger to render said trigger effective when said gas is at a predetermined pressure.

8. Aspirating apparatus comprising, in combination, a body portion formed with an opening, closure means mounted on said body portion for sealing said opening, means mounted on said body portion for urging said closure means to seal said opening, aspirating means positioned adjacent said opening for directing gas under pressure through said opening, means supported by said body portion for supplying gas under pressure to said aspirating means, latch means mounted on said closure means for normally retaining said closure means open, a trigger connected to said latch means for rendering said latch means ineffective, a cylinder mounted on said body portion, pressure responsive means in said cylinder in fluid flow communication with said gas supplying means, and a shaft connected at one end to said pressure responsive means and formed with means for engaging said trigger at its other end to render said trigger effective when said gas is at a predetermined pressure.

9. Aspirating apparatus comprising, in combination, a body portion formed with an opening, closure means pivotally mounted on said body portion for sealing said opening, spring means mounted on said body portion for urging said closure means to seal said opening, aspirating means positioned adjacent said opening for directing gas under pressure through said opening, means supported by said body portion for supplying gas under pressure to said aspirating means, keeper means on said body portion, a latch member pivotally mounted on said closure means adapted to engage said keeper means to retain said closure means open, a trigger pivotally mounted on said latch member for effecting disengagement of said latch member and said keeper means, a cylinder mounted on said body portion and having an inlet in fluid flow communication with said gas supplying means, bellows responsive to the pressure of said gas having an end wall in said cylinder, and a shaft having one end abutting said end wall and engaging said trigger at its other end to render said trigger effective when said gas is at a predetermined pressure.

10. Aspirating apparatus comprising, in combination, a body portion formed with an opening, closure means pivotally mounted on said body portion for sealing said opening, spring means mounted on said body portion for urging said closure means to seal said opening, aspirating means positioned adjacent said opening for directing gas under pressure through said opening, means supported by said body portion for supplying gas under pressure to said aspirating means, keeper means on said body portion, a latch member pivotally mounted on said closure means adapted to engage said keeper means to retain said closure means open, means on said body portion for urging said latch member into keeper engagement, a trigger formed with a projection pivotally mounted on said latch member for effecting disengagement of said latch member and said keeper means to render said spring means effective, a cylinder mounted on said body portion and having an inlet in fluid flow communication with said gas supplying means, bellows responsive to the pressure of said gas having an end wall in said cylinder, a shaft having one end abutting said end wall and provided with a projection at its other end formed to engage said trigger projection, spring means for normally urging said shaft in a direction to cause said projections to engage to render said trigger effective when said pressure is at a predetermined value, and means on said closure means for urging said trigger into projection engaging position.

11. Aspirating apparatus comprising, in combination, a body portion formed with an opening, closure means mounted on said body portion for closing said opening, nozzle means positioned adjacent said opening for directing gas under pressure towards said opening, air flow inducing means mounted on said body portion between said nozzle means and said opening adapted to deliver a volume of air through said opening, means supported by said body portion for supplying gas under pressure to said nozzle means, means on said body portion for normally retaining said closure means open, and pressure

sensitive means in fluid flow communication with said gas supplying means and operatively engaging said retaining means to render said retaining means ineffective when said gas is at a predetermined pressure.

12. Aspirating apparatus comprising, in combination, a body portion formed with an opening, closure means mounted on said body portion for closing said opening, nozzle means positioned adjacent said opening formed with aperture means for directing gas under pressure towards said opening, air flow inducing means mounted on said body portion and extending between said nozzle means and said opening adapted to deliver a volume of air through said opening, means supported by said body portion for supplying gas under pressure to said nozzle means, means on said body portion for normally retaining said closure means open, and pressure sensitive means in fluid flow communication with said gas supplying means operatively engaging said retaining means to render said retaining means ineffective when said gas is at a predetermined pressure.

13. Aspirating apparatus comprising, in combination, a body portion formed with an opening, closure means mounted on said body portion for sealing said opening, a torus-shaped member positioned adjacent said opening provided with an annular passageway, a plurality of apertures in said member for directing gas under pressure towards said opening, air flow inducing means mounted on said body portion and extending between said member and said opening adapted to deliver a volume of air through said opening, means supported by said body portion for supplying gas under pressure to said passageway, means on said body portion for normally retaining said closure means open, and pressure sensitive means in fluid flow communication with said gas supplying means and operatively engaging said retaining means to render said retaining means ineffective when said gas is at a predetermined pressure.

14. Aspirating apparatus comprising, in combination, a body portion formed with an opening, closure means mounted on said body portion for sealing said opening, a torus-shaped member positioned adjacent said opening provided with an annular passageway, a second member having a passageway radially disposed within said first mentioned member in fluid flow communication with said first mentioned passageway, a plurality of apertures in said members for directing gas under pressure towards said opening, air flow inducing means mounted on said body portion between said members and said opening adapted to deliver a volume of air through said opening, means supported by said body portion for supplying gas under pressure to said passageways, means on said body portion for normally retaining said closure means open, and pressure sensitive means in fluid flow communication with said gas supplying means and operatively engaging said retaining means to render said retaining means ineffective when said gas is at a predetermined pressure.

15. Aspirating apparatus comprising, in combination, a body portion formed with an opening, closure means mounted on said body portion for sealing said opening, nozzle means positioned adjacent said opening for directing gas under pressure towards said opening, a tube mounted in said opening and extending towards said nozzle means adapted to deliver a volume of air through said opening, means supported by said body portion for supplying gas under pressure to said nozzle means, means on said body portion for normally retaining said closure means open, and pressure sensitive means in fliud flow communication with said gas supplying means and operatively engaging said retaining means to render said retaining means ineffective when said gas is at a predetermined pressure.

16. Aspirating apparatus comprising, in combination, a body portion formed with an opening, closure means mounted on said body portion for sealing said opening, a torus-shaped member positioned adjacent said opening provided with an annular passageway, a second member having a passageway radially disposed within said first mentioned member in fluid flow communication with said first mentioned passageway, a plurality of apertures in said members adapted to direct gas under pressure towards said opening, a tube mounted in said opening and extending towards said members adapted to deliver a volume of air through said opening, means supported by said body portion for supplying gas under pressure to said passageways, means on said body portion for normally retaining said closure means open, and pressure sensitive means in fluid flow communication with said gas supplying means and operatively engaging said retaining means to render said retaining means ineffective when said gas is at a predetermined pressure.

17. Aspirating apparatus comprising, in combination, a body portion formed with an opening, closure means mounted on said body portion for closing said opening, aspirating means positioned adjacent said opening for directing gas under pressure through said opening, means supported by said body portion for supplying gas under pressure to said aspirating means, means on said body portion for urging said closure means to close said opening, means on said body portion for normally retaining said closure means open, pressure sensitive means in fluid flow communication with said gas supplying means and operatively engaging said retaining means to render said retaining means ineffective and said closure urging means effective when said gas is at a predetermined pressure, and manually controlled reset means mounted on said body portion for rendering said closure urging means ineffective and said closure retaining means effective.

18. Aspirating apparatus comprising, in combination, a body portion formed with an opening, hinge means mounted on said body portion, a closure mounted on said hinge means for closing said opening, aspirating means positioned adjacent said opening for directing gas under pressure through said opening, means supported by said body portion for supplying gas under pressure to said aspirating means, means on said body portion for urging said closure in a direction to close said opening, means on said body portion for normally retaining said closure open, pressure sensitive means in fluid flow communication with said gas supplying means and operatively engaging said retaining means to render said retaining means ineffective and said closure urging means effective when said gas is at a predetermined pressure, and manually controlled reset means including a lever mounted on said body portion for engaging said hinge means and move the same against the influence of said closure urging means to render said retaining means effective.

19. Aspirating apparatus comprising, in combination, a body portion formed with an opening, hinge means pivotally mounted on said body portion, a closure mounted on said hinge means for sealing said opening, aspirating means positioned adjacent said opening for directing gas under pressure through said opening, means supported by said body portion for supplying gas under pressure to said aspirating means, means on said body portion for urging said closure in a direction to seal said opening, means on said body portion for normally retaining said closure open, pressure sensitive means in fluid flow communication with said gas supplying means operatively engaging said retaining means to render said retaining means ineffective and said closure urging means effective when said gas is at a predetermined pressure, a lever pivotally mounted on said body portion for engaging said hinge means to move the same against the influence of said closure urging means to render said retaining means effective, and a shaft provided with gripping means at one end thereof slidably journalled in said body portion for engaging said lever at the other end thereof to effect pivotal movement thereof.

20. Aspirating means comprising, in combination, a body portion formed with an opening, hinge means pivotally mounted on said body portion, a closure

mounted on said hinge means for sealing said opening, aspirating means positioned adjacent said opening for directing gas under pressure through said opening, means supported by said body portion for supplying gas under pressure to said aspirating means, means on said body portion for urging said closure towards said opening to seal the same, latch means on the hinge means for normally retaining said closure means open, a trigger connected to said latch means for rendering said latch means ineffective, pressure sensitive means in fluid flow communication with said gas supplying means and engaging said trigger to render said trigger effective when said gas is at a predetermined pressure, and reset means including a lever mounted on said body portion for engaging said hinge means and move the same in a direction against the influence of said closure urging means to render said latch means effective.

21. Aspirating means comprising, in combination, a body portion formed with an opening, hinge means pivotally mounted on said body portion, a closure mounted on said hinge means for sealing said opening, aspirating means positioned adjacent said opening, means for directing gas under pressure through said opening for supplying gas under pressure to said aspirating means, means on said body portion for urging said closure towards said opening to seal the same, latch means on the hinge means for normally retaining said closure means open, a trigger connected to said latch means for rendering said latch means ineffective, pressure sensitive means in fluid flow communication with said gas supplying means and engaging said trigger to render said trigger effective when said gas is at a predetermined pressure, a lever pivotally mounted on said body portion for engaging said hinge means to move the same against the influence of said closure urging means to render said latch means effective, and a shaft provided with gripping means at one end thereof slidably journalled in said body portion for engaging said lever at the other end thereof to effect pivotal movement thereof.

22. Aspirating means comprising, in combination, a body portion formed with an opening, an annular member adjacently spaced outwardly from said opening to provide an air space between said annular member and said opening and having a passageway provided with a plurality of circumferentially spaced outlet apertures arranged to direct gas under pressure through said opening, and means for supplying gas under pressure to said passageway.

23. Aspirating means comprising, in combination, a body portion formed with an opening, an annular member having a passageway adjacently spaced outwardly from said opening, a second member radially disposed within said first member having a passageway in fluid flow communication with said first mentioned passageway, a plurality of apertures in said members arranged to direct gas under pressure through said opening, and means for supplying gas under pressure to said passageways.

24. Aspirating means comprising, in combination, a body portion formed with an opening, a tube mounted in said opening having an open end, an annular member having a passageway adjacently spaced outwardly from said open end of said tube, a plurality of circumferentially spaced apertures in said member arranged to direct gas under pressure through said tube and said opening, and means for supplying gas under pressure to said passageway.

25. Apparatus according to claim 24, wherein the end of said tube adjacent said member is flared outwardly.

26. Aspirating apparatus comprising, in combination, a body portion formed with an opening, a tube mounted in said opening, a torus-shaped member having a passageway adjacently outwardly spaced from one end of said tube, a second member radially disposed within said first member having a passageway in fluid flow communication with said first mentioned passageway, a plurality of apertures in said members arranged to direct gas under pressure through said tube and said opening, said tube being flared outwardly at its end adjacent said member, said apertures in said member being disposed on the locus of a circle having a diameter no greater than the minimum inside diameter of said tube, and means for supplying gas under pressure to said passageways.

References Cited in the file of this patent

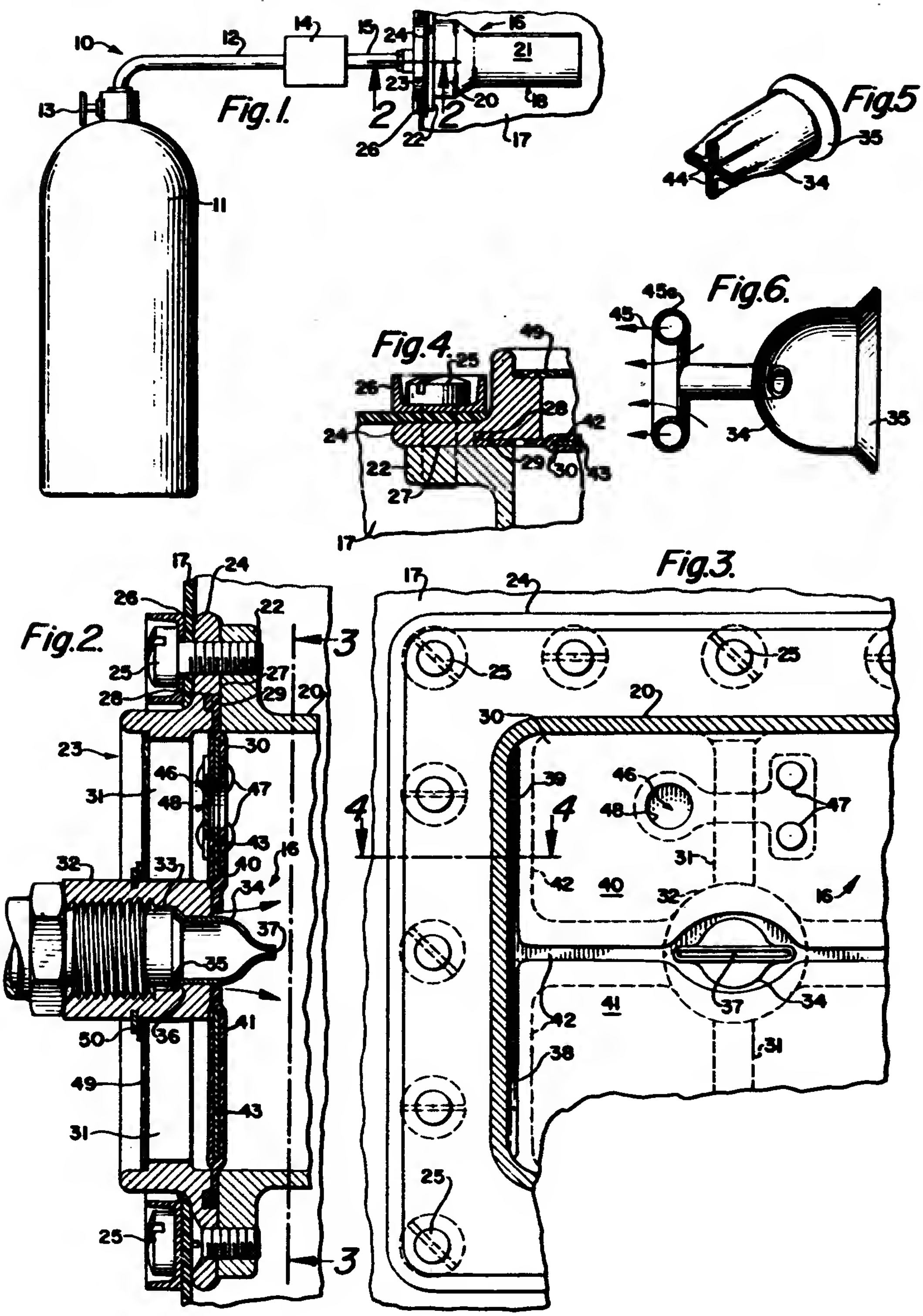
UNITED STATES PATENTS

467,427	McClave	Jan. 19, 1892
871,209	Cotton	Nov. 19, 1907
1,458,810	Dawley	June 12, 1923
1,805,370	Meyer	May 12, 1931
2,399,670	Freygang	May 7, 1946
2,628,020	Koch	Feb. 10, 1953

Dec. 4, 1956 2,772,829

INFLATION ASPIRATOR

Filed May 2, 1955



United States Patent Office

2,772,829
Patented Dec. 4, 1956

1

2,772,829

INFLATION ASPIRATOR

Application May 2, 1955, Serial No. 507,355
(Filed under Rule 47(a) and 35 U. S. C. 116)
8 Claims. (Cl. 230—95)

This invention relates generally to apparatus for inflating devices of any type, such as, lifesaving devices, air mattresses, shelters, construction forms and other structures, which are designed to be filled with air or gases under relatively low pressure. Some articles of such type, particularly lifesaving devices, may be formed of fabric, plastic and/or other suitable materials and are usually stowed in a collapsed condition, and when the occasion for use arises they must be inflated. Since these devices are used in emergencies, the inflation thereof must be comparatively rapid. This invention is more specifically directed to container-inflating apparatus of the type utilizing, as its power source, compressed air or other suitable gases.

An object of this invention is to provide apparatus for inflating a container, such apparatus including a source of compressed gas and a jet pump or aspirator of a novel design which functions to induce a flow of air from the atmosphere into the bag to effect a quicker, more efficient inflation of the container than has been possible with prior apparatus.

Another object of this invention is to provide a container-inflating apparatus having an improved jet pump or aspirator which has a body of tubular configuration, a nozzle for directing a jet-like stream of air or gas from a suitable source into or through the body, and check valve elements for admitting ambient air into the body under the inducement of the flow through the body created by the jet stream, the check valve elements serving to prevent the escape of air from the container.

Still another object of the invention is to provide a receptacle-inflating apparatus with an improved aspirator having a tubular body with check valves at the entrance end and a nozzle terminating, in inwardly spaced relation from the entrance end, in a restricted orifice which directs a jet stream of air from a suitable source, axially through the body to cause a flow of air from the atmosphere past the check valves into the receptacle; the location of the check valves relative to the nozzle provide improved air induction and prevent the loss of air from the receptacle during the last stages of inflation when the source pressure falls below a predetermined value.

Another object of the invention is to provide an aspirator having a tubular body with a nozzle for directing a jet stream of air therethrough to induce a flow of atmospheric air into the body, the latter being provided with one or more check valves arranged between the nozzle and the atmospheric air inlet so that although the check valves will readily open to admit atmospheric air, the jet stream from the nozzle will not strike the check valve and tend to hold it open, which would permit escape of air when the jet stream becomes too weak to induce an inflow of atmospheric air.

Another object of the invention is to provide an aspirator having a tubular body with a rectangular cross-section at the inlet end, so that one or more check

2

valves having large area may be used to admit air from the atmosphere, the check valves being supported for swinging movement adjacent the periphery of the inlet end of the body in order to assist in directing the induced atmospheric air toward the swiftly flowing jet, thus prolonging the aspirating cycle during final stages of flow from the compressed air source.

A further object of the invention is to provide the aspirator referred to in the previous paragraphs with a safety, pressure relief or limiting valve which prevents the pressure in the receptacle from exceeding a predetermined maximum in the event the receptacle should be exposed to sunlight or other source of heat which might cause the air therein to expand, or in the event flow of air from the compressed source through the nozzle continues after the closing of the check valves and the pressure in the receptacle tends to increase beyond the predetermined maximum; the relief valve thus serves to determine the final pressure in the receptacle.

Other objects and advantages will be apparent from the following description taken in connection with the accompanying drawing in which one form of the invention has been illustrated.

In the drawings:

Figure 1 is a diagrammatic view of apparatus for inflating collapsible containers, such apparatus having a jet pump or aspirator formed in accordance with the invention.

Figure 2 is a detail horizontal sectional view taken through the aspirator on the plane indicated by the line 2—2 of Figure 1.

Figure 3 is a vertical transverse sectional view taken on the plane indicated by the line 3—3 of Figure 2.

Figure 4 is a detail horizontal sectional view taken on the plane indicated by the line 4—4 of Figure 3.

Figure 5 is a perspective view of a modified type of jet nozzle which may be used in the aspirator forming the subject matter of the invention.

Figure 6 is a vertical sectional view through a further modified type of jet nozzle.

Referring more particularly to the drawings, the numeral 10 designates the inflating apparatus in its entirety. This apparatus includes a tank or bottle 11 containing air under relatively high pressure. A conduit 12 is connected with the outlet portion of the container, this conduit containing a shut-off valve 13 of any suitable type. The conduit leads from the shut-off valve to a regulator 14 employed to reduce the pressure of the air or other fluid issuing from the tank 11 to a desired value and to maintain the air flowing from the regulator at the predetermined pressure. A conduit 15 leads from the regulator 14, which may be of any suitable type, such as shown in our co-pending application Serial No. 507,356, filed on even date herewith, to a jet pump or aspirator 16 which forms the subject matter of this invention. The member 16, as pointed out in the objects, is secured in the inlet of a collapsible container, such as a fabric or plastic bag 17, a portion only of which has been illustrated in the drawing. The bag 17 may be a life raft, an escape slide, or other type of lifesaving device provided for use in airplanes and other personnel-transporting equipment. In most instances the bag is formed from suitably treated fabric which may be collapsed to reduce the space required for stowage.

The aspirator 16 has been provided to effect a rapid inflation of the bag 17. This aspirator includes a tubular body 18 which, in the present instance, has an inlet end 20 of rectangular or square cross-section which converges into an outlet portion 21 having a circular cross-section. The inlet section 20 is provided with an external flange 22 to which is secured a frame 23. This frame is also rectangular, to conform to the inlet section 20, and

has a peripheral flange 24 in which openings are provided for the reception of screws or other fastening devices employed to secure the frame to the body 18. Flanges 22 and 24 are also provided with openings, certain of which are threaded to receive fastening elements 25 which secure a channel-sectioned clamp 26 to the aspirator and serve to unite the latter and the bag 17, the connection between the aspirator and bag being made airtight by squeezing the latter between the clamp and the frame. The frame 23 has the surface 27 thereof, which engages body 18, provided with a groove 28 for the reception of a peripheral bead 29 formed on a rubber or other flexible plate-like member 30, this member being inserted between the frame 23 and the body 18 when the former is being assembled with the latter. The screws employed to fasten the frame to the body cause the frame to clamp the edge of the rubber member 30 in airtight relationship with the body. The member 30 provides check valves for permitting atmospheric air to flow into the bag and prevents the escape of such air therefrom.

The frame 23, in the present illustration, has ribs 31 extending from the central portions of each side toward the opposite side, these ribs being joined with a boss 32 disposed centrally of the frame, the frame providing a rectangular opening constituting a continuation of the inlet portion of the body 18. Boss 32 has a central opening 33 formed therein, the outer portion of which is threaded to receive the conduit 15. The inner portion of this opening is formed to receive a nozzle 34 formed of metal or other suitable material, the nozzle being of thimble-like shape and being flared, as at 35, to engage and seal against a shoulder 36 in the boss 32. Nozzle 34 may be suitably secured in place in the boss, as by clamping or otherwise, to provide an airtight joint; it terminates at its inner end, in spaced relation from the frame, in a restricted orifice, the first form of the invention showing an elongated slot 37 of substantially rectangular configuration having a length many times greater than its width to cause a jet stream having extended surface. One specimen of the device was found to perform satisfactorily with a jet orifice having a length and width of .600 and .006 inches, respectively. This slit-like orifice causes a fan-shaped jet of air to issue from the nozzle and results in an intimate mixing of the primary and secondary or atmospheric air in the shortest possible length of body 18.

It will be noted from Figure 3 that the member 30 has slots 38 and 39 formed therein to provide substantially rectangular check valve flaps 40 and 41, these flaps being joined with the member 30 along regions located at opposed sides of the inlet section of the body 18. This arrangement permits the valve flaps 40 and 41 to swing into the body without undue interference. The frame 23 is provided, along the sides of the openings formed therein, with flanges 42 for engagement by the valve flaps 40 and 41 to prevent these elements from swinging outwardly under the influence of pressure within the body 18 or the bag 17. When the flap valves engage the flanges, an airtight joint will be formed. The flaps may, if desired, be reinforced by incorporating fabric or metallic sheeting 43 therein during the formation of the member 30. This reinforcement will prevent the flaps from flexing when pressure urges them against the flanges.

It will be noted from Figure 2 that the inner end of the nozzle 34 terminates at a point spaced inwardly from the flap valves. This arrangement is advantageous since it prevents the high velocity air issuing from the nozzle from engaging the flaps and tending to swing the same toward open position. In prior devices of this character, high velocity jets impinged on the check valves and tended to hold them in open position, particularly during the final stages of bag filling. When the check valves were so engaged and held, air escaped from the bag and a complete filling was prevented. With the construction shown, this objection is eliminated.

In the operation of the device, a jet stream of air at high velocity issues from the orifice 37 in the nozzle, mixes with the air in the body 18 and flows through the outlet portion 21 of the body into the bag 17. This flow of air reduces the pressure at the inlet end below the atmospheric pressure existing exteriorly of the bag. The pressure of atmospheric air on the outer surfaces of the flap valves 40 and 41 swings them inwardly toward an open position, permitting the atmospheric air to enter the bag and mix with the jet stream issuing from the nozzle. Since the flap valves 40 and 41 possess relatively large areas, large quantities of air may enter the bag; a rapid filling operation will thus result.

In some instances, improved results may be secured by forming the orifice in the jet nozzle with different configurations, such as illustrated in Figures 5 and 6. In the former figure, the nozzle is provided with a cross-shaped orifice 44, while in Figure 6, the orifice 45 is formed in a hollow ring-like element 45a and has an annular configuration. Other forms may be employed if found desirable, the essential feature of the orifice being a large ratio of jet periphery to cross-sectional area with all of the periphery exposed to induce a flow of ambient air.

During the major portion of the container filling operation or when the pressure of the supply is above a predetermined minimum, the jet stream flowing from the nozzle will have a velocity sufficient to induce a flow of atmospheric air past the check valves 40 and 41. When, however, the pressure at the source is reduced and the velocity of the jet falls, the tendency of the air within the container to flow outwardly through the body will cause the check valves to close. Since the pressure of the air from the source will still be above that of the container, air will continue to flow from the nozzle and tend to increase the pressure in the container. The final pressure of the inflated container may be determined or limited by providing another check valve 46. This valve, however, is disposed on the outside of the device, on the check valve 40 in the illustration, and is responsive to pressure from within the container to open and permit some air to escape. Check valve 46 constitutes a flat plate riveted, or otherwise secured, as at 47, to the valve 40, a portion of the valve covering opening 48. Should the pressure within the container tend to exceed a predetermined value, valve 46 will open and permit some air to escape until the predetermined pressure exists in the container; valve 46 will then close to prevent further escape of air. Normally, valve 46 will then remain in a closed position.

In some instances, the bag may be inflated when the atmospheric air is at a relatively low temperature, then, after being filled, the bag may be exposed to sunlight or other conditions which will cause the air in the bag to heat and expand. Valve 46 will again permit the escape of air to prevent undue pressures from building up in the bag.

The frame 23 may have a suitable screen 49 secured over the openings therein to prevent the entrance of foreign matter. This screen, in the form of the invention illustrated, is held in engagement with the outer surfaces of the ribs 31 and flanges 42 by a snap ring 50 secured in a groove formed in boss 32.

While the invention has been illustrated in one embodiment only, many minor changes may be made in the formation and arrangement of parts without departing from the spirit and scope of the invention as set forth in the following claims.

We claim:

1. In apparatus for inflating a container, an aspirator comprising a tubular body having inlet and outlet ends, said body being formed for attachment to the container to be inflated; check valve means at the inlet end of said body, said check valve means being movable between an open position providing for the entrance of atmospheric air into said container and a closed position preventing

the escape of air from said container; and nozzle means projecting into said body and terminating inwardly beyond said check valve means in a restricted orifice for directing a jet of fluid axially of said body, said nozzle means being formed for communicating with a source of fluid under pressure.

2. In apparatus for inflating a container, an aspirator comprising a tubular body formed for attachment to the container to be inflated, said body having inlet and outlet ends; a supporting frame at the inlet end of said body; a nozzle carried by said frame and projecting into said body, said nozzle being formed for communication with a supply of fluid under pressure and provided with a restricted outlet for directing a jet of fluid axially of said body; and check valve means carried by said frame to provide for the flow of atmospheric air into said tubular body and prevent fluid escape therefrom, said check valve means being disposed in closer proximity to the inlet end of said body then said nozzle.

3. In apparatus for inflating containers, an aspirator comprising a tubular body formed for attachment to a container to be inflated, said body having inlet and outlet ends; a jet nozzle projecting into said body at the inlet end substantially in the axial center thereof, said nozzle being formed for communication with a source of compressed gas; and a check valve supported adjacent the wall of said tubular body at the inlet end thereof for swinging movement into the body to provide for the entrance of air at atmospheric pressure, outward swinging movement of said check valve being limited to prevent outflow of air from said body.

4. In apparatus for inflating containers, an aspirator comprising a tubular body formed for attachment to a container to be inflated, said body having inlet and outlet ends; a jet nozzle projecting into said body at the inlet end substantially in the axial center thereof, said nozzle being formed for communication with a source of compressed gas; and a pair of check valves supported adjacent opposite walls at the inlet end of said body, said check valves being mounted for swinging movement into the body to provide for the entrance of atmospheric air thereinto, outward swinging movement of said check valves being limited to prevent outflow of air from said body.

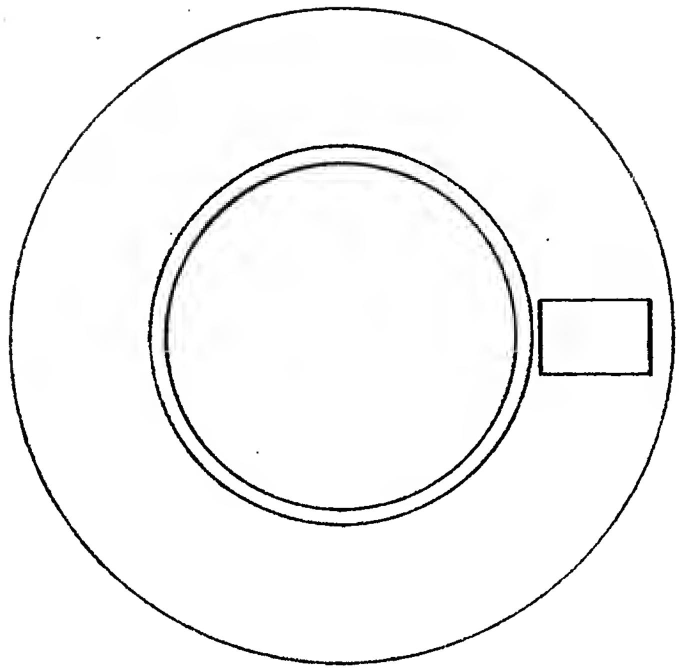
5. In apparatus for inflating a container, an aspirator comprising a tubular body having inlet and outlet ends, said body being formed for attachment to the container to be inflated; a nozzle disposed at the inlet end of and projecting into said body, said nozzle being formed for communication with a source of fluid under pressure and having a restricted outlet disposed in the longitudinal axis of said body for directing a jet of fluid axially thereof; and check valve means at the inlet end of said body to provide for atmospheric airflow into said tubular body and prevent fluid escape therefrom, said check valve means being located between the outlet of said nozzle and the inlet end of said body.

6. In apparatus for inflating a container, an aspirator comprising a tubular body with inlet and outlet sections joined by a converging section, said body being formed for attachment to the container to be inflated; a nozzle disposed axially of said inlet section and terminating inwardly from the entrance end thereof in a slit-like orifice for directing a jet of fluid at high velocity axially of said body, said nozzle being formed for communication with a source of fluid under pressure; and check valve means at the entrance end of the inlet section of said body to provide for the induction of atmospheric air into said body and to prevent fluid escape therefrom.

7. In apparatus for inflating a container, an aspirator comprising a tubular body of rectangular cross-section at the inlet end, said body being formed for attachment to a container to be inflated; check valve means supported adjacent predetermined edges of the inlet end of said body for movement between open and closed positions to provide for the entrance of atmospheric air into said container and to prevent airflow therefrom; and a nozzle supported at the inlet end of and projecting into said body, said nozzle terminating in a restricted orifice for directing a jet of fluid axially of said body, said nozzle being formed for communication with a source of fluid pressure.

8. In apparatus for inflating a container, an aspirator comprising a tubular body having inlet and outlet ends, said body being formed for attachment to the container to be inflated; check valve means at the inlet end of said body, said check valve means being movable between an open position providing for the entrance of atmospheric air into said container and a closed position preventing the escape of air from said container; nozzle means projecting into said body and terminating inwardly beyond said check valve means in a restricted orifice for directing a jet of fluid axially of said body, said nozzle means being formed for communication with a source of fluid under pressure; and a relief valve provided on said aspirator for limiting the pressure in said container to a predetermined maximum.

No references cited.



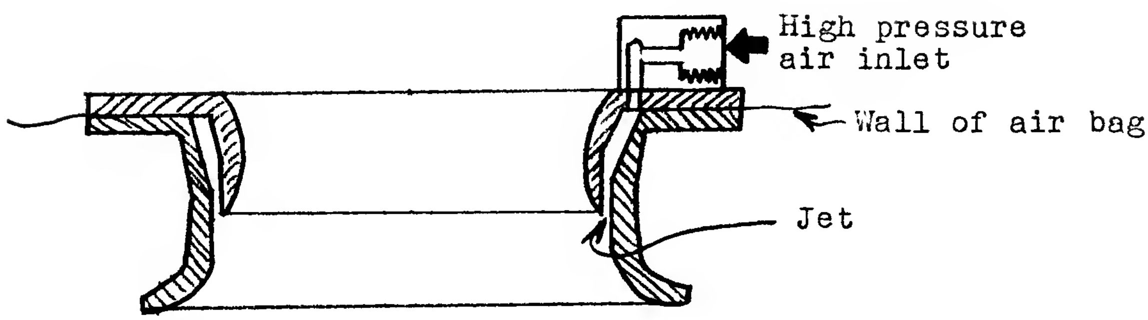


EXHIBIT 5 — Sketch of Working Model of Annular Ring Jet Used to Determine First Approximations to Sizes and Proportions

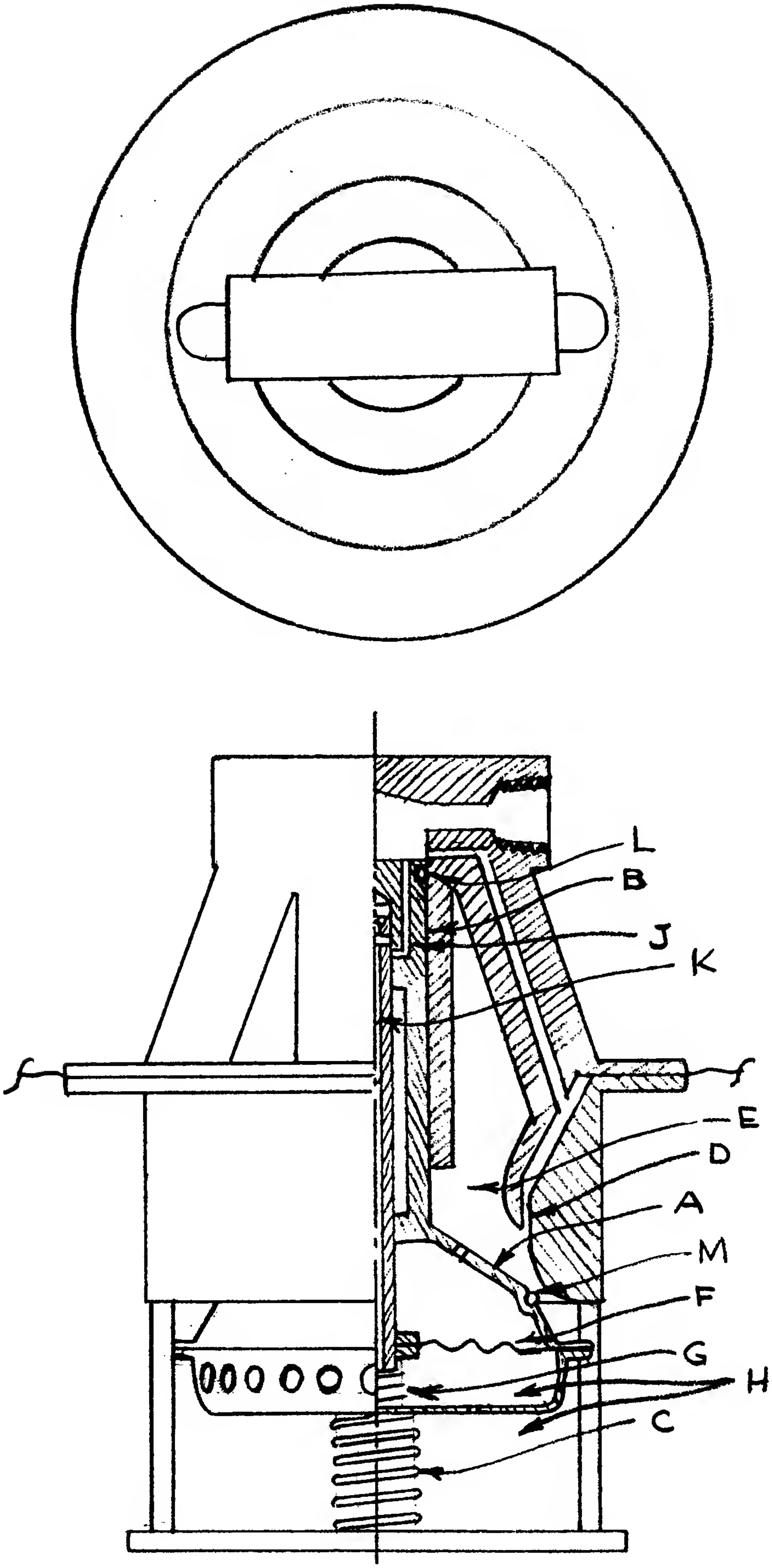


EXHIBIT 6 — Sketch of First Band Co. Experimental Aspirator (Approximately Full Size).

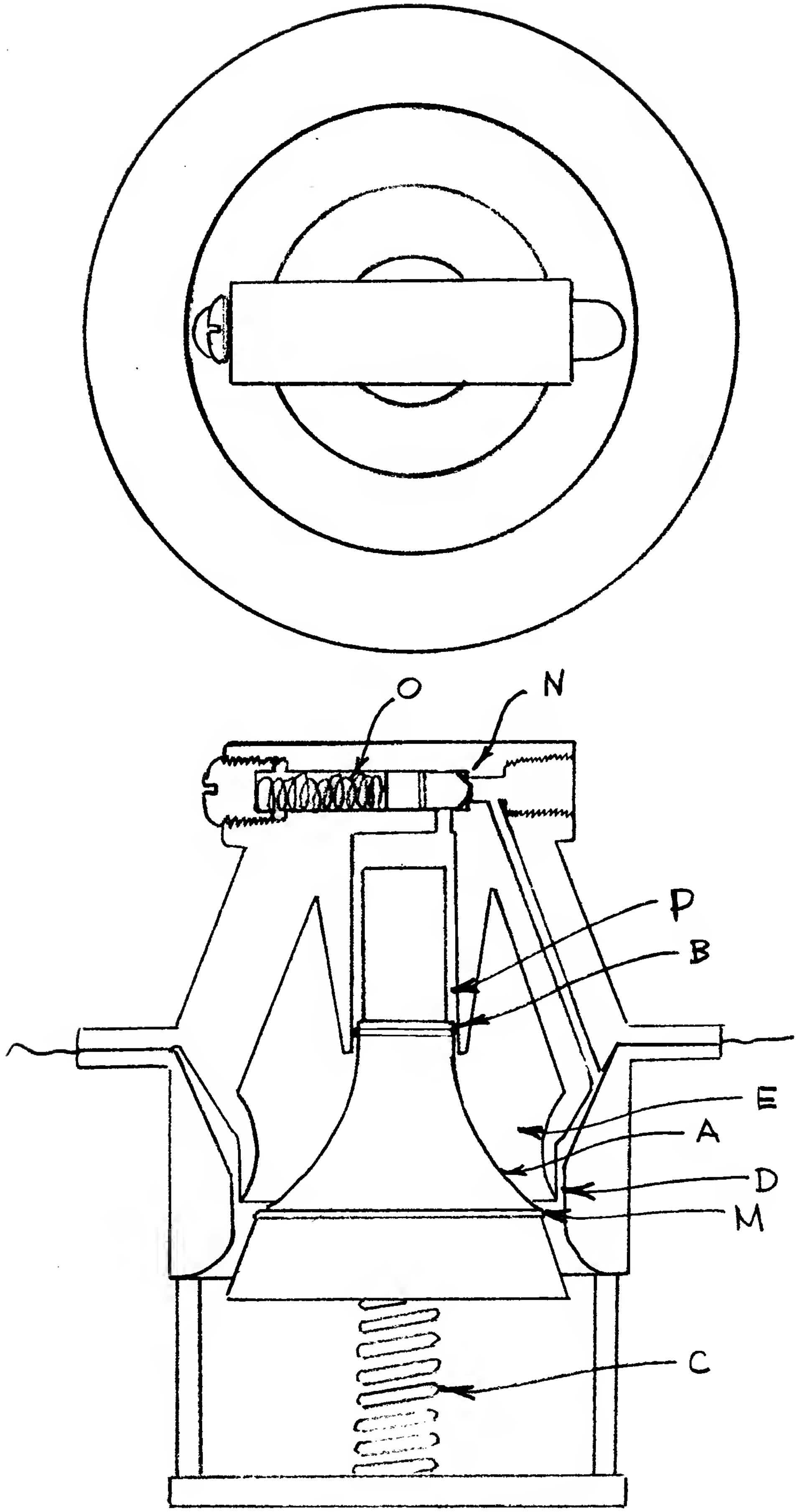


EXHIBIT 7 — Sketch of Band Co. Final Aspirator Design (Approximately Full Size)

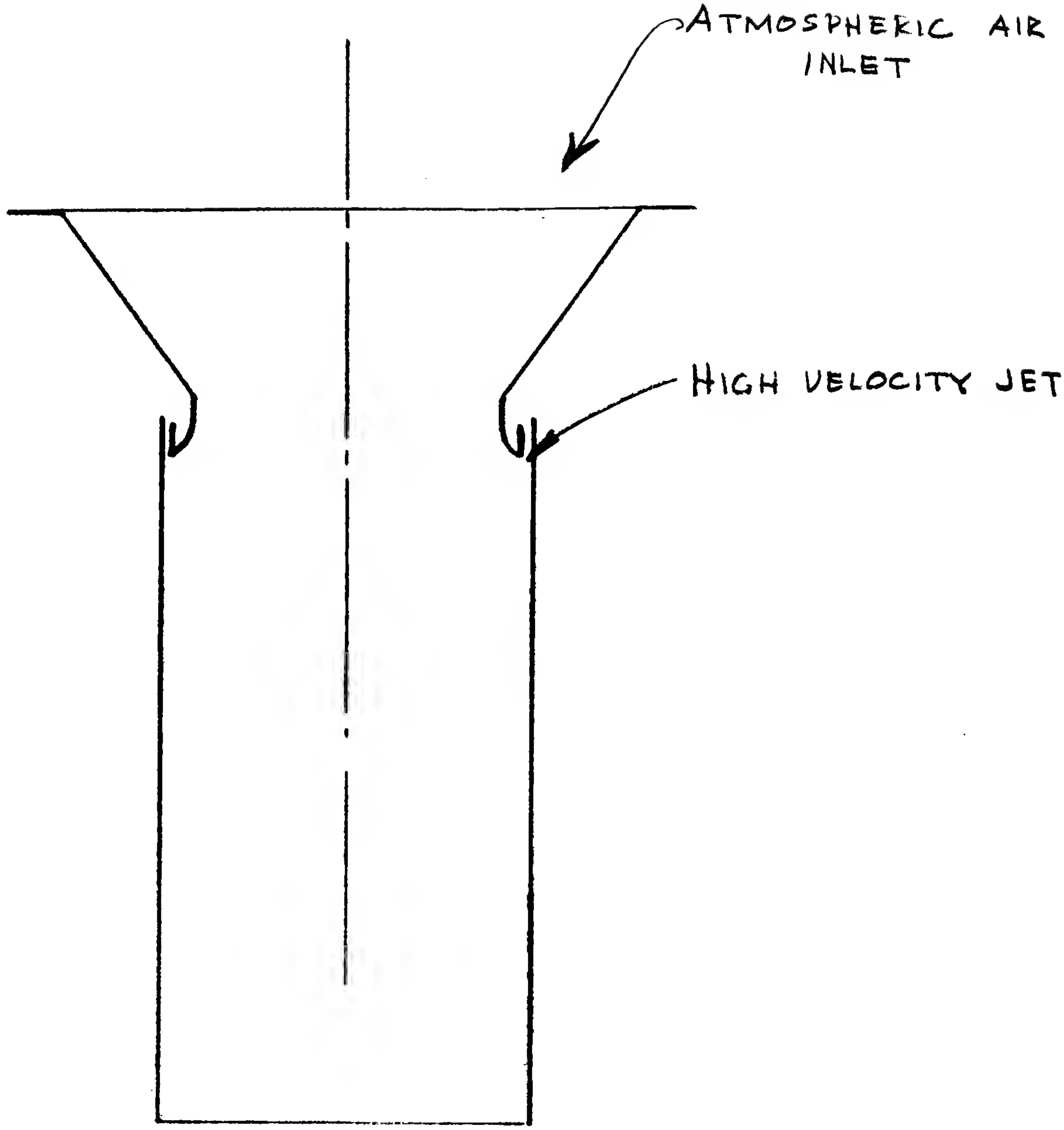


EXHIBIT 8 — Proportions of Aspirator Throat Determined From Laboratory Test of Two Dimensional Model with Relatively Low Pressure Supply Air

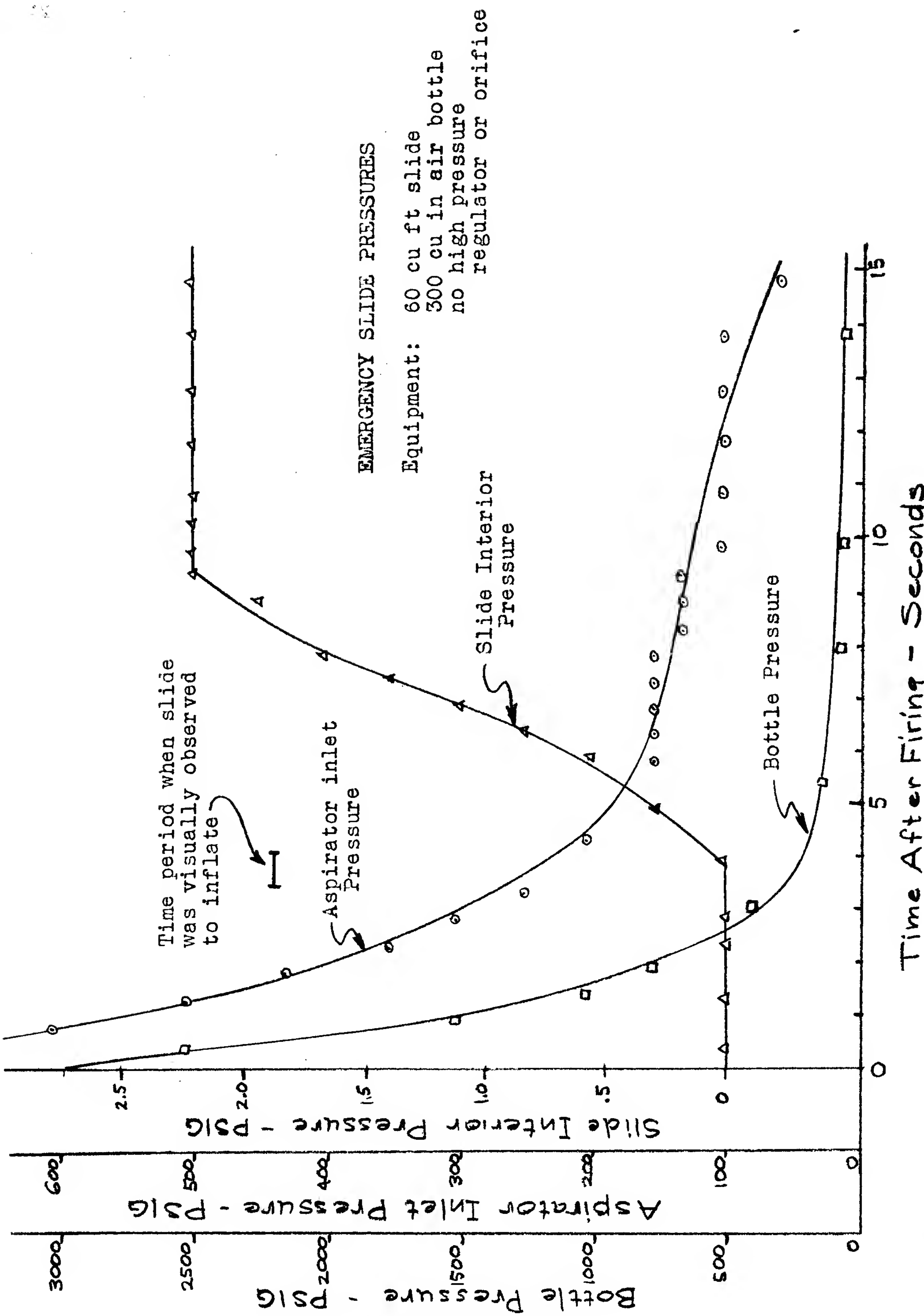


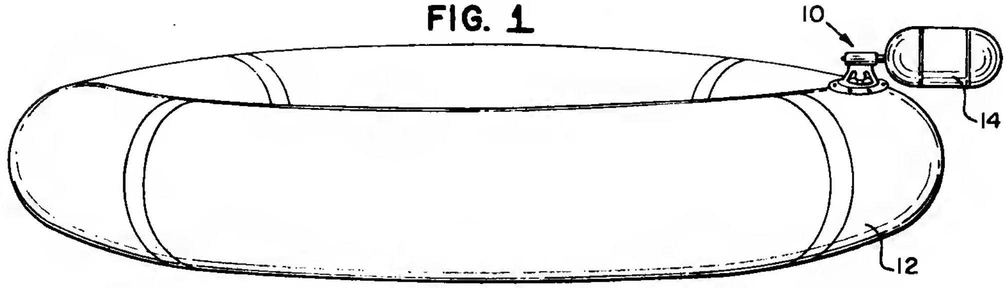
EXHIBIT 9 — Slide Pressure Curves

Aug. 29, 1967 T. J. ZILKA ETAL 3,338,266

INFLATION INCITER

Filed April 1, 1964

FIG. 1



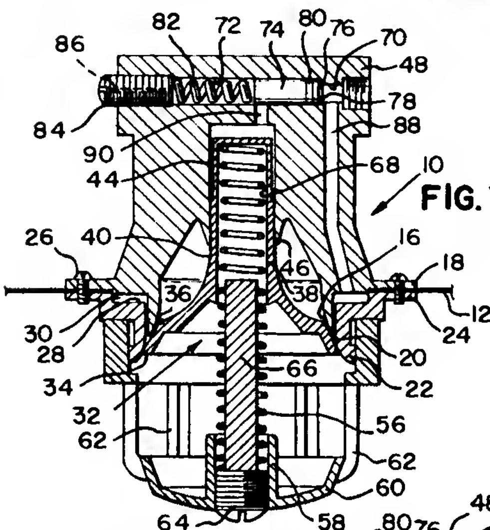


FIG. 3

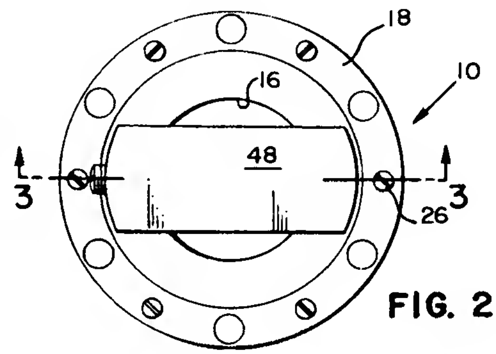


FIG. 2

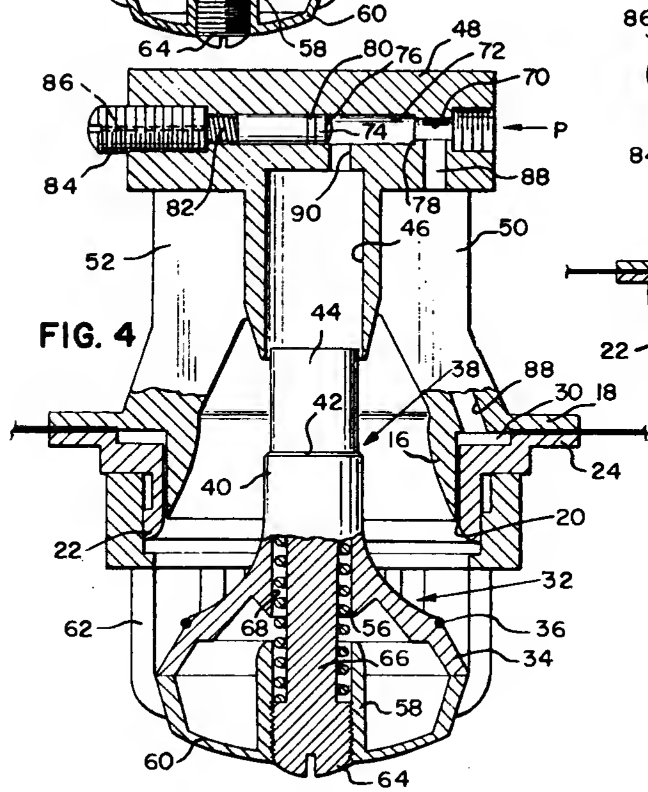


FIG. 4

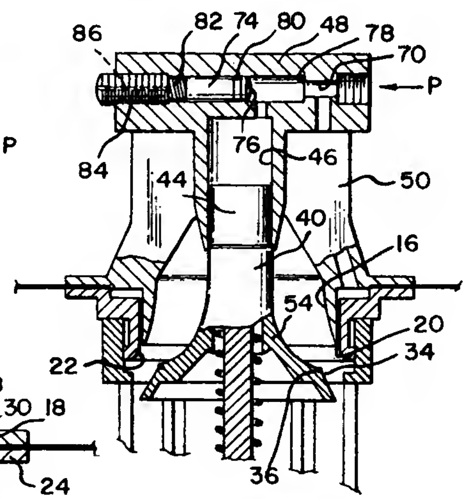


FIG. 5

INVENTORS
THOMAS J. ZILKA

Melvin R. Stidham
ATTORNEYS

United States Patent Office

3,338,266
Patented Aug. 29, 1967

1

3,338,266
INFLATION INCITER
Thomas J. Zilka Mill Valley, Calif., assignors to Company, Sausalito, Calif., a sole proprietorship of Thomas J. Zilka
Filed Apr. 1, 1964, Ser. No. 356,501
16 Claims. (Cl. 137—604)

This application relates to an inflation inciter and, more particularly, to a valve-operated device adapted to project high velocity gas streams to promote the flow of ambient air for the inflation of non-rigid articles such as life rafts.

Many non-rigid articles such as life rafts, aircraft escape slides, and the like, are best stored aboard an aircraft or vessel in compact, folded condition and inflated when needed by operation of a self-contained source of pressure fluid, such as a small storage tank or bottle of pressurized air, carbon dioxide or other gas. However, when such inflatable articles are of particularly large volume, the gas supply tank must also be of correspondingly large volume, and often the point is reached wherein the stored article is of excessive weight and unwieldy to handle. Others have conceived the principle of employing a small quantity of pressurized fluid and directing its flow so as to incite and promote ambient air with it into the article being inflated and this invention is directed to an application of that principle.

It is, therefore, an object of this invention to provide a compact flow inciter device capable of inciting the flow of a large volume of ambient air with a relatively small quantity of pressurized fluid.

It is a further object of this invention to provide a flow inciter device that projects pressurized fluid at a high rate of flow through a large venturi throat initially, which venturi is reduced in size to compensate for reduction in pressure and flow rate.

It is a further object of this invention to provide a flow promoter valve that is efficient and reliable in operation and relatively economical to manufacture.

In carrying out this invention, we provide a flow inciter device having a central venturi flow passage portion with means around the outside to secure it in an opening in a life raft or other inflatable article. An annular nozzle extends around the orifice to project a jet of fluid therethrough at a high velocity to accelerate ambient air through the passage and draw additional air into the low pressure zone created. The orifice is adapted to be closed by a bell-shaped poppet valve that is urged axially into sealing relationship with the venturi by means of a strong spring. The portion of the valve projecting toward the inlet end of the venturi is of reduced diameter to form a trailing piston of enlarged diameter and a leading piston of reduced diameter both of which are extended into a cylinder carried on the valve body when the poppet valve is in closed position. Fluid conduits connect the source of pressure fluid to both the annular nozzle and the cylinder initially to drive the piston down with a force sufficient to carry the enlarged piston out of the cylinder and provide a clearance around the reduced piston through which a second stream of air projects through the venturi. Then, as the pressure subsides, the spring forces the piston back into the cylinder until the enlarged portion enters to shut off most of the flow in the central area while fluid continues to project out of the annular nozzle. Finally, when the pressure reaches a minimum level, a check valve in the fluid conduit prevents further flow to the central cylinder permitting the pistons to extend fully into the cylinder and force the poppet valve into sealing engagement with the venturi on the intake side of the annular nozzle. Flow through the annular nozzle will continue until the pressure in the inflatable article equals that in the pressure fluid storage bottle.

2

Other objects and advantages of this invention will become apparent from the description following when read in conjunction with the accompanying drawings, wherein:

FIG. 1 is a view in perspective of a life raft with a valve attachment embodying features of this invention;

FIG. 2 is a top plan view of an air flow inciter embodying features of this invention;

FIG. 3 is a section view taken along line 3—3 of FIG. 2; and

FIGS. 4 and 5 are views partially cut away showing the valve in fully opened and partially opened stages, respectively.

Referring momentarily to FIG. 1, the air promoter valve of this invention **10** is shown mounted on non-rigid inflatable article such as a life raft **12**, the inflation thereof having been incited by flow of pressure fluid from a source **14** in a manner hereinafter to be described. Of course, the life raft is only a typical installation in which this invention may be applied but, generally, it is useful in non-rigid articles of relatively large volume that desirably are inflated at a very rapid rate.

Referring now to FIGS. 2 to 4, the essential elements of this invention include a venturi flow duct **16** carrying a radial flange **18** adapted to extend beyond the edge of an opening in the inflatable article **12** with the venturi duct **16** opening into the article. Around the inner surface of the venturi **16** is an annular nozzle **20** which is formed by a complementary member **22** having an inner surface forming a continuation of the outward flare to constitute the delivery end of the venturi. The delivery end portion **22** also has an integral flange **24** which may be secured to the flange **18** by suitable means such as screws **26** to clamp the edges of the inflatable article between them in sealing relationship. The upper portion of the member **22** is stepped downward at **28** below the plane of the flange **24** in order to provide an annular passage **30** communicating directly with the annular nozzle **20**.

The venturi **16** is adapted to be closed against fluid flow by means of a poppet-type valve **32** having a generally frustro-conical skirt portion **34** around which is carried a resilient seal **36** of a diameter to engage the venturi **16** in an annular sealing contact at a point on the intake side of the nozzle opening **20**, i.e., above the nozzle. Integral with the valve closure member **32** is a piston extension **38** having an enlarged trailing end **40** merging at a shoulder **42** into a reduced leading portion **44**. The enlarged trailing portion **40** is of a diameter to fit snugly within a cylinder **46** opening downward from a pressure fluid intake manifold **48** supported above the venturi duct on suitable leg members **50** and **52**. Consequently, the leading portion **44** fits within the cylinder **46** with an annular clearance that will permit flow of fluid around it as will hereinafter be described. As shown clearly in FIGS. 3, 4 and 5 the trailing piston portion **40** flares outward at **54** to merge smoothly into the frustoconical skirt **34**.

The valve 32 is urged into closed position by means of a strong compression spring 56 extending between a socket 58 carried on the bottom plate 60 of a cage formed by depending support arms 62. Preferably, the socket 58 is internally threaded to accommodate the threaded end 64 of a spring guide rod 66 which prevents radial displacement of the spring 56 and the spring is similarly restrained at the other end by accommodation within a bore 68 extending into the piston portion 38 of the poppet valve 32. The guide rod 66 besides supporting the spring 56 serves as a stop to limit the downward movement of the valve 32. The threaded end 64 affords a means for adjusting the level of stop and preferably the full open position of the valve is as shown in FIG. 4 wherein the poppet valve 34 and the bottom cup 60 form a substantially continuous curved surface for smooth flow of air.

The pressure fluid intake manifold 48 is bored at 70 to provide an inlet passageway for pressure fluid from the source 14 (FIG. 1) and is counterbored at 72 to accommodate slidably a control check valve 74 having a resilient seal 76 at the end thereof to seat against the shoulder 78 at the end of the bore 70. Preferably, an O-ring seal 80 or the like is provided around the body of the valve member 74 in order to prevent leakage around it. The valve 74 is biased into closed position by a compression spring 82, the strength of which is adjusted by a threaded screw 84 that is provided with an axial vent 86 to prevent entrapment of air behind the valve member 74. Communicating with the inlet passageway 70 are outlet ducts 88 and 90 which open into the annular delivery duct 30 and the cylindrical chamber 46, respectively.

In FIG. 3, the valve is shown in its closed position with the spring 56 forcing the resilient seal 36 on the poppet valve 32 firmly against the flared venturi 16 to seal against any flow of fluid through the venturi 16.

Then, when it is desired to inflate an article such as the life raft 12, a source of pressure fluid P is introduced through inlet conduit 70 by operation of any suitable valve means (not shown) associated with the high pressure air bottle 14. The pressure within the air bottle is sufficient first to force the check valve 74 back in the bore 72 to open both ducts 90 and 88, and then as the fluid enters cylindrical chamber 46, to drive the piston 38 down to the position shown in FIG. 4. In certain installations an air bottle pressure of 3,000 p.s.i. has been found satisfactory but the invention is not so limited. The dimensions and proportions of the inciter may be adjusted to operate successfully over a wide range of supply pressures. With the piston in this depressed position, the enlarged trailing portion 40 thereof is completely free of the cylinder 46 and a small clearance exists around the smaller piston portion 44 through which the pressure fluid can exit at high velocity. Thus, an annular jet sheet is projected through the clearance around the upper reduced portion 44 to travel down along the flare 54 of the valve and through the venturi throat between the poppet valve 32 and the venturi passage 16. At the same time, the pressure fluid flowing down into inlet duct 88 in the leg 50 enters the annular chamber 28 to flow out of the annular nozzle 20 and form a concentric jet sheet around the outside of the venturi throat. It is to be noted in FIG. 4 that during the initial operation of the inflation inciter 10 while the poppet valve 32 is displaced downward to its lowermost position, the throat passageway between the valve and the venturi surface 16 is of maximum cross-section.

As the concentric jet streams project from around the upper piston 44 and through the annular nozzle 20 they accelerate the air between them across the throat of the venturi to induce a low pressure region at the throat into which additional atmospheric air rushes.

Then, after the pressure of the incoming fluid P reduces to a predetermined value, the spring 56 tends to overcome the force on the smaller piston 44 and raises the valve 32 until the larger trailing piston 40 engages the cylindrical chamber to the position in FIG. 5. For all practical purposes this stops all but a minimal amount of flow around the piston and, essentially, the only jet stream is that emanating from the annular nozzle 20. However, in the position of the poppet valve 32 in FIG. 5 the frustroconical skirt 34 has moved up to a point adjacent the lower end of the venturi 16 to reduce the size of the throat materially so that the flow velocity will be maintained at a high level, accelerating ambient air and continuing to produce a low pressure region into which more atmospheric air rushes. A third stage in the operation is reached when the pressure P is reduced to a value wherein the small spring 82 behind the check valve overcomes the force of the fluid to bias the check valve 74 against the shoulder 78 and shut off all further flow to the cylindrical chamber 46. At this point, the spring 56 can drive the piston into its fully retracted position, as shown in FIG. 3 wherein the main poppet valve 32 is firmly sealed so that no more ambient air can be brought into the inflated article 12 and, more significantly, air in the inflated article cannot escape. Of course, as long as there is any pressure differential between the pressurized bottle source 14 and the raft 12, fluid will continue to flow through the duct 88 and out through the annular nozzle which, with the main valve 32 closed, is disposed below the seal 36. When a state of equilibrium is reached, there will be no further flow and both vessels will be at the same pressure. In test installations the inflation pressures with an initial pressure of 3,000 p.s.i. have been in the range from 2 to 10 p.s.i. but there is no limit to the final pressure within the scope of this invention except as governed by the supply pressure and the design configuration.

With the check valve 74 sealed against the shoulder 78 and sealed around its periphery by means of the seal 80 there is no way for fluid within the inflated vessel 12 to escape back through the duct 88 and out through the duct 90 and around the piston 38.

While this invention has been described in connection with preferred embodiments thereof, it is to be understood that modifications and changes therein may be made by those skilled in the art without departing from the spirit and scope of this invention as defined by the claims appended hereto.

Having described our invention, we claim:

1. An air flow inciter comprising:

a tubular flow passageway having open, relatively high flow capacity, intake and delivery ends,

the inner surface of said passageway being configurated as a venturi orifice wherein the cross-section of said passageway downstream of said intake end is reduced to a restricted diameter smaller than that of said intake end and increases gradually in an outward flare toward said delivery end,

first nozzle means directed downstream and opening into said passageway upstream of the restricted diameter portion thereof,

annular nozzle means around said passageway directed downstream and opening into said inner surface downstream of said restricted diameter portion,

a pressure fluid inlet adapted to be connected to a source of pressure fluid,

duct means connecting said fluid inlet to said first and said annular nozzles,

a valve closure member cooperatively associated with means at the delivery end of said flow passageway and movable between open and closed positions, respectively, to enable and prevent flow therethrough, a pressure-responsive member connected to said valve closure member to move it between said open and closed positions, a valve actuating conduit connected to said pressure fluid inlet to expose said pressure responsive member to said pressure fluid and thereby bias said valve closure member toward open position, and

yieldable means biasing said valve closure member toward closed position.

2. The air flow inciter defined by claim 1 including:
a vessel forming a cylindrical chamber carried on said passageway with the axis thereof in alignment with said venturi and with an open end thereof disposed toward said delivery end of the venturi,
a piston member carried on said valve closure member slidably received in said cylindrical chamber,
a valve actuating conduit communicating between said pressure fluid inlet and said cylindrical chamber, and
yieldable means biasing said valve closure member toward closed position.

3. The air flow inciter defined by claim 2, including:
a check valve in said valve actuating conduit conditioned to open said conduit by action of fluid pressure against it, and
a spring biasing said check valve closed.

4. The air flow inciter defined by claim 3, including:
an annular resilent seal member of said valve closure member engageable with said venturi-forming inner surface on the intake side of said annular nozzle means.

5. The air flow inciter defined by claim 2 wherein:
said piston member has a leading portion of reduced diameter and a trailing portion of an enlarged diameter to fit snugly within said cylindrical member,
said first nozzle comprising the clearance within said cylindrical chamber around said portion of reduced diameter,
said yieldable means being overcome by pressure in said cylindrical chamber above a predetermined level to force the trailing portion of said cylinder out of said chamber and permit fluid in said chamber to flow out through said first nozzle.

6. The air flow inciter defined by claim 5 including:
a check valve in said valve actuating conduit conditioned to open said conduit by action of fluid pressure against it, and
a spring biasing said check valve closed,
said spring being overcome by pressure in said valve actuating conduit below said predetermined level.

7. The air flow inciter defined by claim 6 including:
an annular resilent seal member on said valve closure member engageable with said venturi-forming inner surface on the intake side of said annular nozzle means.

8. The air flow inciter defined by claim 1 including:
a vessel forming a cylindrical chamber carried in alignment with said flow passageway with an open end thereof disposed adjacent the intake end of said flow passageway and directed toward said delivery end thereof,
a piston member fixedly carried on said valve closure member and received in said cylindrical chamber for axial movement therealong to move said valve closure member therewith between open and closed positions,
surface portions extending from said piston member and flaring outward to merge with said valve closure member,
a valve actuating conduit communicating between said pressure fluid inlet and said cylindrical chamber,
said piston member being conditioned to be biased outward of said cylindrical chamber by pressure fluid in said cylindrical chamber to move said valve closure member toward open position,
said first nozzle comprising a radial clearance between said piston and said chamber through which pressure fluid biasing said piston may simultaneously flow around it along said surface portions through said flow passageway, and
yieldable means biasing said valve towards closed position.

9. The air flow inciter defined by claim 8 wherein:
said piston member has a leading portion of reduced diameter and a trailing portion of enlarged diameter to fit snugly within said cylindrical chamber,
said yieldable means being overcome by pressure in said cylindrical chamber above a predetermined level to force the trailing portion of said cylinder out of said chamber and permit fluid in said chamber to flow out around said leading portion.

10. The air flow inciter defined in claim 9 including:
a check valve in said valve actuating conduit conditioned to open said conduit by action of fluid pressure against it, and
a spring biasing said check valve closed,
said spring being overcome by pressure in said valve actuating conduit below said predetermined level.

11. The air flow inciter defined by claim 8, including:
an annular resilent seal member on said valve closure member engageable with said venturi-forming surface on the intake side of said annular nozzle means.

12. The air flow inciter defined by claim 9 including:
a frusto-conical skirt member depending from said valve closure member,
said skirt member being disposed and arranged to move into radial alignment with said delivery end of the venturi when pressure in said cylindrical chamber falls below said predetermined level to permit said trailing portion of the piston member to enter snugly within said cylindrical chamber.

13. The air flow inciter defined by claim 12, including:
an annular resilient seal member on said valve closure member engageable with said venturi-forming surface on the intake side of said annular nozzle means.

14. An air flow inciter comprising:
a tubular flow passageway having open intake and delivery ends,
a valve closure member cooperatively associated with the delivery end of said passageway and movable axially between open and closed positions, respectively to permit and prevent flow of fluid therethrough,
a vessel forming a cylindrical chamber carried in alignment with said flow passageway with an open end thereof disposed adjacent the intake end of said passageway and directed toward said delivery end of the passageway,
a piston member fixedly carried on said valve closure member and received in said cylindrical chamber for axial movement therealong to move said valve closure member therewith between open and closed positions,
surface portions extending from said piston member and flaring outward to merge with said valve closure member,
a pressure fluid inlet for connection to a source of pressure fluid,
a valve actuating conduit communicating between said inlet and said cylindrical chamber,
said piston member being conditioned to be biased outward of said cylindrical chamber by pressure fluid in said cylindrical chamber to move said valve closure member toward open position,
said first nozzle comprising a radial clearance between said piston and said chamber through which pressure fluid biasing said piston member may simultaneously flow around it along said surface portions through said delivery end, and
yieldable means biasing said valve closure member toward closed position.

15. The air flow inciter defined by claim 14 wherein:
said piston member has a leading portion of reduced diameter with said radial clearance surrounding it and a trailing portion of enlarged diameter to fit snugly within said cylindrical chamber,

said yieldable means being overcome by pressure in said cylindrical chamber above a predetermined level to force the trailing portion of said cylinder out of said chamber and permit fluid in said chamber to flow out around said leading portion.

16. The air flow inciter defined by claim **15** including:

a check valve in said valve actuating conduit conditioned to open said conduit by action of fluid pressure against it, and

a spring biasing said check valve closed,

said spring being overcome by pressure in said valve actuating conduit below said predetermined level.

References Cited

UNITED STATES PATENTS

1,901,797	3/1933	Black	103—263
2,444,717	7/1948	Allen	9—11
2,794,447	6/1957	Spitz	137—604
3,010,232	11/1961	Skakel et al.	103—262 X

FOREIGN PATENTS

196,366	3/1958	Austria.

WILLIAM F. O'DEA, *Primary Examiner.*

D. H. LAMBERT, *Assistant Examiner.*

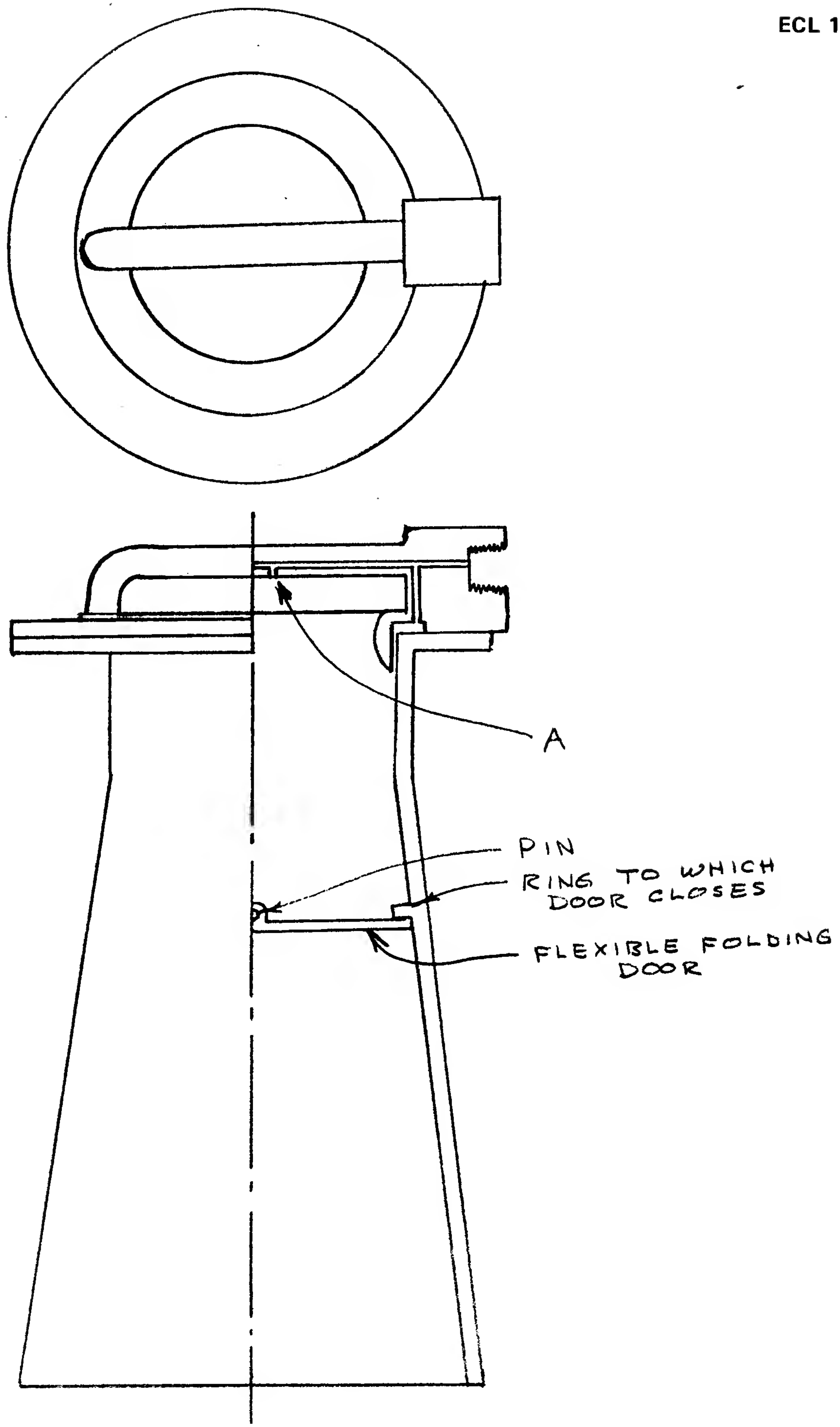


EXHIBIT 11 — Sketch of Final Airslide Corp. Design